

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*. Some elements of the description are partly 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 characteristic. 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 status 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 characteristics 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 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 and behavior interchange patterns 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*).

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

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Variable	Brief description	Range
$N_i$	State on a nominal social distinction that splits the agent population into two categories	$N_i \in \{A;B\}$
$S_i$	Belief about the relation between the social distinction $N_i$ and general competence. When the value of $S_i$ is equal to one of the two possible states of $N_i$ , the focal agent believes that agents with the respective state on $N_i$ are more competent than agents with the other state. When $S_i = O$ , the focal agents does not believe that $N_i$ is related to competence differences	$S_i \in \{A;O;B\}$
$e_{ij}$	Performance expectation that a given agent $i$ has for agent $j$ ; agents also hold performance expectations for themselves, so that $i = j$	$-1 \leq e_{ij} \leq 1$
$E_i$	Transformed average performance expectation that all agents (including agent $i$ ) have for agent $i$ .	$0 \leq E_i \leq 1$

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**Behavior interchange patterns:** Ties between dyads of agents that indicate which of the members of a dyad held more/less often the higher competence role in all past interactions between them

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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.	$0 \leq weight \leq \infty$

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### 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 and assign them initial values on all their variables.

For each agent, determine the performance expectations  $e_{ij}$  it has for all group members, including itself (submodel: `update_performance_expectations`).

Create a variable that stores the number of changes in the measure *cons* that have already occurred (from here on `changes_cons`). Set the value of `changes_cons` to 0.

Create a variable that stores the value of *cons* at the end of an iteration (from here on `previous_cons`). Set the value of `previous_cons` to 0.

Set the values of *comp*, *cons*, *changes\_cons*, *r*, *largest\_share\_of\_agents\_with\_status\_belief* 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*

```
Create a variable that stores the number of iterations that
  have already been conducted (from here on
  number_iterations). Set the value of number_iterations
  to 0.
```

```
While number_iterations  $\leq$  max_number_iterations:
```

```
{
```

```
  For each agent, update the transformed average
    performance expectation  $E_i$  that group members have
    for it, including itself (submodel: update_Eis).
```

```
  For all agents, create a temporary variable that stores
    the value of  $E_i$ , weighted by  $\alpha$  as an exponent (from
    here on  $E_i^\alpha$ , submodel: select_interactants).
```

```
  Randomly select one agent for being interactant_1, with
    a probability proportional to  $E_i^\alpha$  over all agents
    (submodel: select_interactants).
```

```
  Randomly select one agent for being interactant_2 from
    the set of agents that excludes interactant_1, with
    a probability proportional to  $E_i^\alpha$  over all agents
    in this set (submodel: select_interactants).
```

```
  For both interactant_1 and interactant_2, create a
    temporary variable that stores the value of  $E_i$ ,
    weighted with  $\beta$  as an exponent (from here on  $E_i^\beta$ ,
    submodel: interaction).
```

```
  Randomly select interactant_1 or interactant_2 for
    taking the higher competence role in their
    interaction, with a probability proportional to  $E_i^\beta$ 
    over both agents; assign the respective other agent
    the lower competence role (submodel: interaction).
```

```
  Update the behavior interchange pattern/tie between
    interactant_1 and interactant_2, based on the
    outcome of their interaction, so that:
  {
```

```

If: Interactant_1 has the higher competence
role in the current interaction with
interactant_2:
{
    If: There is no behavior interchange
    pattern/tie between interactant_1
    and interactant_2 yet, or there is
    a pattern for which the tie is
    undirected and has weight = 0,
    create a directed tie/change the
    tie, so that interactant_1 is the
    source and interactant_2 is the
    sink; set the tie's weight = 1.

    Else, if: A behavior interchange
    pattern/tie between interactant_1
    and interactant_2 exists that has
    weight > 1:
    {
        If: The pattern/tie is
        directed so that
        interactant_1 is the
        source and interactant_2
        is the sink, increase the
        tie's weight by 1.

        Else, if: The pattern/tie is
        directed so that
        interactant_1 is the sink
        and interactant_2 is the
        source, decrease the tie's
        weight by 1.
    }
    Else, if: A behavior interchange
    pattern/tie between interactant_1
    and interactant_2 exists that has
    weight = 1:
    {
        If: The pattern/tie is
        directed so that
        interactant_1 is the
        source and interactant_2
        is the sink, increase the
        tie's weight by 1.

        Else, if: The pattern/tie is
        directed so that

```

```

        interactant_1 is the sink
        and interactant_2 is the
        source, decrease the tie's
        weight by 1 and make it
        undirected.
    }
}
Else, if: Interactant_2 has the higher
competence role in the current interaction
with interactant_1:
{
    If: There is no behavior interchange
    pattern/tie between interactant_1
    and interactant_2 yet, or there is
    a pattern for which the tie is
    undirected and has weight = 0,
    create a directed tie/change the
    tie, so that interactant_2 is the
    source and interactant_1 is the
    sink; set the tie's weight = 1.

    Else, if: A behavior interchange
    pattern/tie between interactant_1
    and interactant_2 exists that has
    weight > 1:
    {
        If: The pattern/tie is
        directed so that
        interactant_2 is the
        source and interactant_1
        is the sink, increase the
        tie's weight by 1.

        Else, if: The pattern/tie is
        directed so that
        interactant_2 is the sink
        and interactant_1 is the
        source, decrease the tie's
        weight by 1.
    }
}
Else, if: A behavior interchange
pattern/tie between interactant_1
and interactant_2 exists that has
weight = 1:
{
    If it the pattern/tie is
    directed so that

```

interactant\_2 is the source and interactant\_1 is the sink, increase the tie's *weight* by 1.

Else, if: The pattern/tie is directed so that interactant\_2 is the sink and interactant\_1 is the source, decrease the tie's *weight* by 1 and make it undirected.

}  
}

Calculate *comp*, *cons*, and *r* (submodels: calculate\_comp, calculate\_cons, and calculate\_r)

If *cons* has changed its sign compared to the last iteration, increase the value of *changes\_cons* by 1

Set *previous\_cons* to the value of *cons*

For each agent, update its status belief  $S_i$  (submodel: update\_status\_beliefs)

For each agent, update the performance expectations  $e_{ij}$  it has for all group members, including itself (submodel: update\_performance\_expectations)

Calculate *largest\_share\_of\_agents\_with\_status\_belief* (submodels: calculate\_largest\_share\_of\_agents\_with\_status\_belief)

Report *comp*, *cons*, *changes\_cons*, *r*, *largest\_share\_of\_agents\_with\_status\_belief*

Increase the value of *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 here 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 status. One central question addressed in this framework is how task focused groups might develop hierarchical differentiation if there are no obvious differences among group that might 'justify' status differences (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 in groups with a collective task focus, individuals act "as if one of the[ir] subtasks is to decide who has high and who has low ability at the task—thus to take advantage of high ability members and not to be misled by low ability members" (Driskell 1982, p. 232). Assumptions about relative abilities are represented by *so-called performance expectations* (Berger et al. 1977; Webster and Sobieszek 1974) that group members hold for each other.

Performance expectations affect the way group members coordinate their work on the task. 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, receive more often the opportunity to make suggestions, and are given more time to elaborate their views (Balkwell 1991a; Berger, Rosenholtz, and Zelditch 1980; Correll and Ridgeway 2003). 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 (Fisek et al. 1991; Webster and Rashotte 2010).

When individuals lack objective information about each other's competence, they look for cues that might provide such information. Two cues that are relevant in the context of our model are *status characteristics* and *behavior interchange patterns*. Status characteristics are connected to beliefs about competence differences between members of different social categories. For instance, when sex 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  $A_1$  often appreciates and accepts the suggestion of group member  $A_2$ , whereas  $A_2$  often 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 (Fisek et al. 1991; Webster and Rashotte 2010).

When there are status differences between social categories from the outset, the expectation states framework argues that the foregoing processes have the tendency to create stable

hierarchical differentiation between group members, even in the absence of objective competence differences. In the presence of salient status characteristics, individuals who belong to status advantaged categories are from the outset more likely to dominate interactions, because the performance expectations that group members have for them are relatively higher than for group members who belong to status disadvantaged categories. This leads to a “self-fulfilling prophecy” (Meecker 1994, p. 107) in which external status differences will lead to differences in hierarchical positions. In the absence of salient status characteristics, group members who early manage to make suggestions that are accepted by other group members, even if only by coincidence, increase the performance expectations that other group members have for them. As a consequence, they are more likely to receive subsequent performance opportunities and their subsequent suggestions are more likely to be evaluated positively.

The foregoing implies that small, randomly created status differences tend to grow and become stable over time, even if there are no objective resource or competence differences among group members (Fiske et al. 1991).

### **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, p. 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, pp. 96-97). Comprehensive means that individuals have observed a number of behavior interchange patterns between different members of different social categories. Consistent means that in these patterns members of one category generally held the higher status position, whereas members of the respective other category almost invariably held the lower status position. 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 (Ridgeway and Correll 2006).

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. Acting against such consensus bears the risk of social backlash that can incur significant costs for the individual. This creates a subjective incentive to comply with the perceived consensus (Ridgeway and Correll 2006).

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. This shift in probabilities implements the notion that group members adapt their behavior when seemingly task relevant information (in the form of behavior interchange patterns) 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.

## 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 groups. 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 three 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 the largest share of group members with a stare on  $S_i$  that is different from  $S_i = 0$ , and we measure how often *cons* changes its sign over the course of a simulation run. All measures are calculated at the end of each iteration.

## 2.11 Initialization

We used groups of size four, six, eight, and ten. All groups are equally divided into agents belonging to each of the two categories (i.e. to  $N_i = A$  and  $N_i = B$ ). Initially, no agent holds a status belief (i.e. all  $S_i = 0$ ), and initially there are not behavior interchange patterns among them. The values of the exogenous parameters  $\alpha$  and  $\beta$  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. Submodels

### 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. 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* (Webster, Whitmeyer, and Rashotte 2004). The performance expectation  $e_{ij}$  that agent  $i$  has for  $j$  at iteration  $t$  is modeled as

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

where  $\#neg_{ij}$  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 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; Balkwell 1991b).

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 transformed average expectation that group members have for agent  $i$ . 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  $E_i^\alpha$ . Subsequently, the receiver of this suggestion is randomly selected from the set of remaining group members, also with a probability proportional to  $E_i^\alpha$ . In both cases,  $\alpha$  ( $\alpha \geq 0$ ) is an exogenous weighting factor that enables us to control the extent to which interactions concentrate among the higher ranking group members. When  $\alpha = 0$ , 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  $\alpha$  becomes, the more likely it becomes that agents for whom group members have on average relatively higher performance expectations become selected as senders or receivers of suggestions. In the *random interaction model*, 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).

### 3.2. 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  $E_i^\beta / (E_i^\beta + E_j^\beta)$  and the probability that  $j$  will reject  $i$ 's suggestion is equal to  $1 - E_i^\beta / (E_i^\beta + E_j^\beta)$ . In both cases,  $\beta$  ( $\beta \geq 0$ ) is an exogenous weighting factor that enables us to control the extent to which performance expectations affect interactions. When  $\beta = 0$ , 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  $\beta$  becomes, the more a difference between  $E_i^\beta$  and  $E_j^\beta$  to the advantage (disadvantage) of  $i$  increase the probability that  $j$  will accept (reject)  $i$ 's suggestion. Note that we use here the (transformed version of) the average performance expectation group members have for  $i$  and  $j$  ( $E_i$ ), rather than using the performance expectations that  $i$  and  $j$  personally have for each other ( $e_{ji}$ ). 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*, 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 instance, presented by Balkwell (1991a)

### 3.3 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  $S_i$  and in which at least one interaction has taken place, divided by the total number of dyads of agents who differ in  $S_i$  (regardless of whether they have already interacted or not).

### 3.4 calculate\_cons

We capture the consistency of the observed hierarchical structure 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 and assess whether agents who belong to category  $A$  appeared more often in the higher or lower competence role in their interactions with agents with who belong to category  $B$ . More technically, we model  $cons$  as

$$cons_t = \frac{\#A_t^- - \#A_t^+}{\#A_t^- + \#A_t^+ + \#A_t^0}, \quad (3)$$

where  $\#A^-$  and  $\#A^+$  are the number of behavior interchange patterns in which agents who belong to the category  $N_i = A$  are in the lower or higher competence role respectively;  $\#A^0$  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.

### 3.5 calculate\_r

Together  $comp$  and  $cons$  determine how strongly the structure of behavior interchange patterns in the group supports a status belief, from agents' point of view. 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 member 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 merely coincidental deviations from well-established hierarchical structures (cf. Ridgeway 2000).

### 3.6 update\_status\_beliefs

Agents acquire (and maintain) status beliefs when the observed structure of behavior interchanges patterns sufficiently supports them. We assume that agents perceive a given belief as sufficiently supported when the value of  $r$  crosses the threshold  $c$  (with  $0 \leq c \leq 1$ ), 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  $0 \leq a \leq 1$ ); 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 lose it with probability  $l$  ( $0 \leq l \leq 1$ ). 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 lose it with probability  $l$ . Note that 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.

### 3.7 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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