# Chapter 14
# Modeling the Culture of Online Collaborative Groups with Affect Control Theory

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**Abstract** We review Affect Control Theory (ACT) as a promising basis for equipping computational agents in social simulations with a sense of sociality. ACT is a computational theory that integrates sociological insights about the symbolic construction of the social order with psychological knowledge about cognitive-affective mechanisms. After explaining the theoretical foundations of ACT and applications of the theory at the dyadic and group level, we describe a case study applying the theory from an ongoing research project examining self-organized online collaboration in software development.

**Keywords** Culture · Affect · Group dynamics · Digital collaboration

## Modeling Culture: A Challenge for Social Simulation

Much recent discussion has revolved around the question of aligning social simulation with relevant theories in psychology and sociology. One aspect of this debate is how to implement behavior rules and decision-making algorithms that reflect psychological knowledge about bounded rationality, heuristics, emotions etc. [e.g., 1–3]. A second problem relates to sociality; i.e., modeling the emergence of a social order out of agent interactions, reflecting properties of human and primate groups such as fights about status, identity, group cohesion, or cultural rules about appropriate relationships [cf. 4].

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In this paper, we outline how Affect Control Theory (ACT), an established social psychological theory of social interaction as emerging from an emotional desire to align one's identity with culturally shared beliefs about the social order [5, 6], can be used to equip artificial computational agents with a sense of sociality. ACT, with its dual roots in psychology and sociology, speaks to the problems of psychologically realistic decision making and artificial sociality alike. We briefly review the theory and some of its applications before we describe ACT-based simulations of group dynamics in online collaborative networks. These simulations emphasize the aspect of hierarchical versus egalitarian structures in such groups, an important and ubiquitous facet of work culture [7]. The goal of this paper is thus twofold: (1) to make the community of social simulation scholars aware of a theoretical tradition that we think very useful for grounding agents in social psychology; and (2) to contribute toward understanding through social simulation contemporary, and increasingly relevant, forms of digital collaboration.

## Affect Control Theory (ACT)

### *Intellectual Roots and Theoretical Components of the Theory*

ACT links social perception with identity, behavior, and emotion in social interactions. The theory draws on *symbolic interactionism* [6, 8–10], proposing that people rely on culturally shared meanings for social concepts to efficiently interpret and respond to social events and anticipate the behavior and emotions of others [5, 6]. We internalize these meanings as we are socialized into our culture, through language acquisition and our encounters with others, and they have tremendous influence on our interpretations of and responses to the world around us. We are motivated to maintain alignment between our interpersonal behavior and this basic cultural knowledge, and tend to behave in ways that are culturally appropriate.

The cognitive mechanism that produces alignment of interpersonal behavior with cultural meanings, according to ACT, is our desire to maintain *coherent mental representations*, a core psychological motive according to well-known classical theories of balance, cognitive dissonance, and -nowadays- parallel constraint satisfaction [11–14]. While these theories differ in scope and detail, the common denominator is that humans are assumed to seek states of mind where all elements of their cognitive representations have a good mutual semantic fit, while inconsistent mental models are perceived as aversive and motivate either reappraisals or changes of the situation.

From modern neuroscience we know that cognition is inseparable from affect [14, 15]. Accordingly, ACT assumes that the alignment of social behavior with cultural norms is a subtle process, driven by *affective processes and intuition* more than by conscious thought. The theory uses cultural affective meanings associated with identity, behavior, and emotion labels to model how humans interpret and respond to social events. Meanings are measured on three universal semantic

dimensions (referred to collectively as EPA) [16]: evaluation (good versus bad), potency (weak versus strong), and activity (calm versus excited), corresponding to the basic dimensionality of human emotion and social interaction [17, 18].

Unlike most other, predominantly qualitative, symbolic interactionist approaches, ACT employs *mathematical formalization.* Affective meanings are represented as vectors in the affective EPA space, based on empirical measures in large-scale surveys using an established semantic-differential technique [16]. Shared cultural knowledge expressed on EPA dimensions describes and differentiates social concepts, which possess characteristic patterns of affective meaning known as fundamental sentiments (**f**). These reflect how good, powerful, and active particular identities, behaviors, or emotions seem in general, outside of the context of social events. Perceptions shift, however, when concepts appear together within social events. Event-contextualized EPA meanings, known as transient impressions ($\boldsymbol{\tau}$) and modeled with regression equations [5], capture our interpretation of actors, behaviors, and other elements of a situation and predict our behavioral and emotional responses to unfolding events.

Our social actions are planned and carried out to either maintain situational meanings or to bring them back into *alignment with cultural expectations* about appropriate behavior and emotions for the identities involved in an event. When expectations are violated, we experience *deflection* ($D$), a sort of tension about the situation that signals a discrepancy between our current experiences and cultural expectations. In line with cognitive consistency theories (see above), people seek to minimize deflection by acting in ways that maintain cultural expectations about the situation. Deflection is calculated, in ACT, as the sum of the squared Euclidean distances between transient impressions $\boldsymbol{\tau}$ of the identities and behaviors emerging from a situation (between a given "actor" and "object-person") and fundamental sentiments **f** for these event elements summed over EPA dimensions (with weights $w_i$):

$$D = \sum\nolimits_i w_i (f_i - \tau_i)^2 \tag{14.1}$$

ACT's predictions accurately reflect behaviors and emotions experienced in a variety of real-world social interactions, including sentiments and social behavior in domestic partnerships [19], support groups [20], social movement organizations [21], and other interactional contexts. Scholars have found that the motivation to align situational behavior with cultural meanings explains phenomena as diverse as deference patterns based on persons' relative occupational prestige [22], leader responses to employee behavior [23], and the preference for interaction partners that provide identity-consistent feedback [24]—even patterns of interaction among nations [25].

## *Social Simulation Based On ACT*

Given the mathematical formalization of ACT with linear algebra [5], using the theory as a basis for defining computational agents is straightforward. A variety of ACT-based computational models have been developed and applied in the past. ACT's classic simulation model, known as *INTERACT* [26], predicts the culture-specific social dynamics that arise from cultural meanings for identities and behavior by means of empirically parameterized regression models in conjunction with repositories of cultural sentiment data, generating testable predictions about behavioral and emotional responses to social events. Model predictions have been supported by survey, experimental, and naturalistic evidence from a research program spanning several decades [e.g., 23–25].

*BayesACT* is a more recent probabilistic generalization that combines the ideas and empirical strategies of the ACT research program with a Bayesian approach from artificial intelligence, modeling social dynamics as a partially observable Markov decision process [2, 27]. BayesACT agents can represent uncertain knowledge about identities as probability distributions in EPA affective space, model multiple identities in one person, and make improved inferences about identity as interactions unfold. Simulations show that even with large initial amounts of uncertainty, stable and orderly patterns of social interaction emerge after a few rounds of interaction, showing that affective coherence mechanisms can explain human interactions even in the absence of consensual symbolic knowledge about the social order [27].

*Group Simulator* is a turn-based ABM (implemented in Netlogo) that extends ACT to model group interactions [28, 29]. Users can set up identity profiles for each group member and model task groups of sizes ranging from three to twenty-five members. Inheriting INTERACT's social-dynamics equations, Group Simulator predicts group members' behavioral and emotional responses to unfolding events based on the assumption that the agent experiencing the most social tension (i.e., deflection as per Eq. 14.1) will tend to be the next to act. It then calculates the most likely interaction partner by optimizing for the agent that will best confirm the sentiments associated with the actor's self-identity, the object-person's self-identity, and the behavior. In other words, the model simulates a relational process of mutually compatible meaning-making based on deflection-minimization as the optimization mechanism. Besides such identity-based tie formation, Group Simulator predicts the distribution of interpersonal behaviors across Interaction Process Analysis categories, a well-known taxonomy of group behavior [30]. Heise [28, 29] validated Group Simulator's applicability for task groups by replicating empirical findings from a classic study of mock jury deliberations [31].

## Studying Online Collaboration With ACT

### *Hierarchy Versus Equality in Online Collaboration*

As part of a larger, ongoing project aimed at studying open-source software development with ACT [2], we model the influence of work cultures on online collaborations using Group Simulator. The portrayal of online groups in the literature is conflicted. Some scholars emphasize the reputedly consensus-driven, egalitarian nature of open-source groups [32]; others note that successful online collaborations tend to be hierarchical and are often unable to reconcile the ideological expectations of egalitarian co-dependent collaboration with the reality of developing versatile, reliable, and profitable applications [33, 34]. We contribute to the growing literature studying the power dynamics of online groups by examining how roles, identities, and relational norms such as the level of reciprocity and distribution of group member contributions simultaneously influence the expectations and behaviors of group members. In particular, we are interested in comparing the social tension (deflection as per Eq. 14.1) experienced in hierarchical versus egalitarian groups. We hypothesize that more egalitarian groups create more deflection because they lack the clear expectations and relational structures implied by the supervisor-subordinate role-sets [cf. 35] given in hierarchical settings. In contrast, egalitarian groups must repeatedly renegotiate who will take a leading role in the interaction, yielding more potential for the affective expectations of group members to be violated. Preliminary simulations with Group Simulator reported in [2] were in line with our hypothesis, here we expand on these results by studying in more detail how role identities are expressed over repeated group interactions. For example, does an agent broadcast their guidance to the entire group, work through a trusted intermediary, or through a series pairwise interactions? While reciprocation implies greater accessibility and, thus, a shallower power gradient between team members, the ability to address the group for prolonged periods underscores the social distance between the supervisor and her subordinates [36]. Consequently, when considering how a work culture is likely to influence interactions, we need to consider both the meanings of the work identities defining that culture (i.e., their evaluation, potency, and activity) and the impact of the relational norms governing turn-taking.

### *Procedure: Simulation Experiments*

To examine how role configurations and relational norms influence the power dynamics of groups, we conducted two simulation experiments where we compared two role configurations. We refer to these group types as egalitarian and hierarchical, respectively. We address the role configurations featured in each experiment first. As implied by their names, the types differ from each other with respect to the group members' relative potency. We kept the evaluation and activity of the group members

**Table 14.1** Simulation description, parameter settings for study 1 and 2

| Group | E | P | A | Label | Addressing Group % | Reciprocity % |
|---|---|---|---|---|---|---|
| Egalitarian | 1 | 1.5 | 1 | Man (3) | *Varying* | 0.8 |
| Hierarchical | 1 | 2.5 | 1 | Boss (1) | *Varying* | 0.8 |
| | 1 | 0.5 | 1 | Client (2) | | |
| Egalitarian | 1 | 1.5 | 1 | Man (3) | 0.4 | *Varying* |
| Hierarchical | 1 | 2.5 | 1 | Boss (1) | 0.4 | *Varying* |
| | 1 | 0.5 | 1 | Client (2) | | |

*Note* The identity labels come from U.S. sentiment data collected between 2002 and 2004 [26]

in both groups constant at a value of 1 to isolate the effects that relational norms have on power dynamics [but see 38]. The resulting egalitarian and hierarchical groups consist of identities roughly corresponding to EPA ratings for the identity *man* on one hand and the identities *boss* and *client* on the other, based on data from a U.S. cultural context [26].

We compared the effect of addressing the group (as opposed to an individual group member) and reciprocation by conducting two simulation experiments. Specifically, we employed a 2X2X11 design, comparing two group types (egalitarian and hierarchical) with respect to two factors (the proportion of actions directed towards the group and the proportion of actions reciprocated by group members), across eleven settings (one for each 10th percentile difference in the two rates). We conducted 200 simulations of each group type with respect to each factor for each percentile. Each simulation consisted of 500 turns. In the simulations where we varied the address-the-group rate, reciprocity was held constant at 0.8 for these experiments, simulating commonly observed rates of reciprocity in discussion groups [37]. In the simulation experiments varying reciprocity, we kept the percentage of actions directed at the group constant at 0.4. For both experiments, we held group size constant at three; all other parameters were set at their default values as per [28]. Table 14.1 summarizes the role configurations (identity label and number of agents of this type), address-the-group percentages, and reciprocity rates featured in each experiment.

## *Results*

We analyze the results of our simulation experiments in two ways. First, we provide a high-level description of changes in group behavior in response to changes in relational norms by comparing the relative proportions of behaviors in egalitarian and hierarchical groups that fall into four broad types of group behavior identified by Robert Bales and colleagues over the course of a thirty-year research program [28, 30]. These types include: positive socio-emotive (e.g., raving about a repository's app), active task (e.g., reviewing pull requests), passive task (e.g., watching), and negative socio-emotive behaviors (e.g., rejecting pull requests) enacted by group

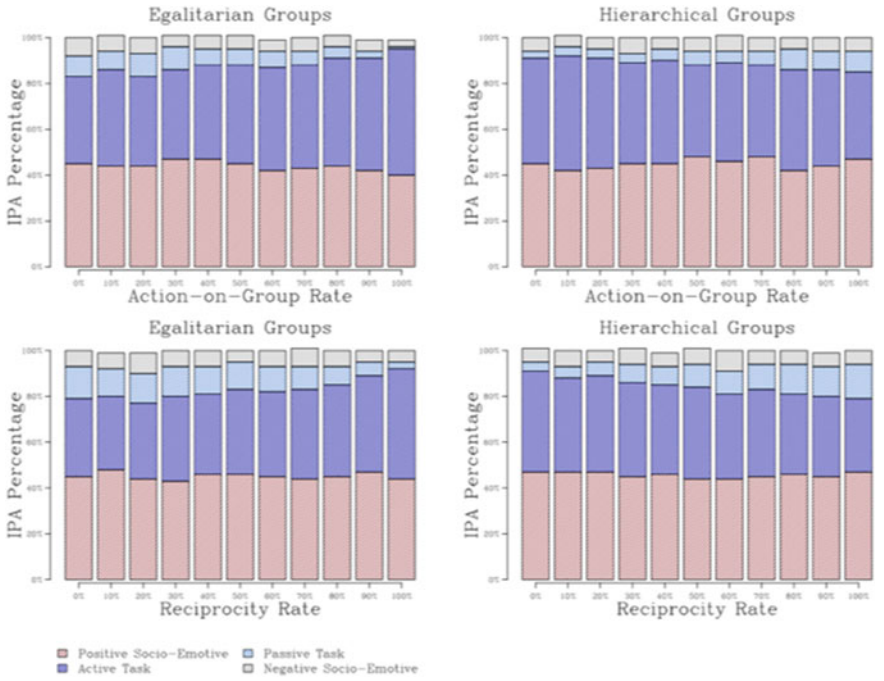


**Fig. 14.1** Predicted percentages of socio-emotive and task behaviors as the percentage of actions addressed to the group and reciprocity change

members. Second, we examine how changes in relational norms influence the median level of deflection experienced by group members. These analyses allow us to demonstrate the varying degree of identity maintenance allowed by the different types of group norms.

**Types of Activities**. Figure 14.1 compares the proportions of behaviors in each category enacted by egalitarian and hierarchical groups (the left and right columns respectively). The figure's rows correspond to changes in the percentage of behaviors addressed to the group, and the percentage of reciprocated behaviors (the top and bottom rows respectively). The x-axis indicates the percentage of behaviors addressed to the group or reciprocated. The y-axis indicates the percentage of behaviors in each behavior category, with the shading indicating the proportion of behaviors in that category. E.g., the second bar in the top left-hand quadrant indicates that groups of men who addressed the group approximately 1 out of 10 times tended to exhibit relatively few negative socio-emotive behaviors and passive task behaviors (7% and 8%, respectively), and many more active task behaviors and positive socio-emotive behaviors (42% and 44%, respectively).

We find that, for both egalitarian and hierarchical groups, the proportion of negative socio-emotive and passive task behaviors shrinks as the percentage of actions directed to the group increases, while the proportion of active task behaviors tends

to grow. For hierarchical groups, the proportion of both negative socio-emotive and passive task behaviors tends to be greater than that of egalitarian groups. These trends are fairly intuitive when considering a few factors.

First, the two groups' role configurations directly influence the likelihood of each behavior type. In egalitarian groups, members' moderately positive identity profile makes more potent negative behaviors such as defying and arguing unlikely because these behaviors tend to be quite negatively evaluated. In contrast, the power difference between clients and bosses makes it more likely that clients will both consult with bosses and, when acted on in ways perceived as aggressive, ignore and evade them.

Second, although the group's role configuration sets basic expectations, the increasing percentage of behaviors directed towards the group also affects the proportion of behaviors in each category. Group members have fewer opportunities to immediately and efficiently resolve interpersonal tensions as the percentage of behaviors directed towards the group increases. Consequently, the agent must act primarily in ways that affirm the entire group's identity. If we evaluate the group as being good and potent, then we will tend to act in ways that support this collective identity. As a result, we see increasingly homogenous behaviors because the identity demands of the group begin to supersede the identity demands of any particular group member.

Figure 14.1 also indicates that norms governing reciprocity also influence the likelihood of different types of behaviors occurring during the group interaction. The bottom two graphs suggest that groups with a stronger expectation that actions will be immediately reciprocated tend to exhibit more diverse sets of behaviors than groups with lower reciprocation rates, with hierarchical groups tending to exhibit greater diversity than egalitarian ones because a greater variety of behavior affirms the group members' respective identities. Bosses can affirm their identity by joking with, directing, or advising the group; clients by asking questions and consulting. In contrast, men affirm their identity by doing the same things: joking with, directing, and generally thumping each other on the back. This difference in the variety of behaviors that affirm the role expectations of the group is indicated in Fig. 14.1 by the relative distribution of behaviors in each category.

Although Fig. 14.1 indicates that strong reciprocation norms have generally the opposite effect of strong norms to direct actions towards the group, it also indicates that norms governing reciprocity can have an even greater impact on the variety of behaviors enacted by the groups. Reciprocity influences the variety of behavior sequences a group is likely to enact because reciprocation norms govern a wider range of potential alters. While norms governing the proportion of actions directed towards the group influence how many actions are directed towards one potential alter (the group), reciprocation norms influence who else the agent will interact with.

As the norm to reciprocate approaches 100%, there is a greater likelihood that the interaction will be dominated by chains of relatively homogeneous reciprocated events. Examples from daily life include chains of seemingly unending pleasantries, affirmations, questions and responses and, more alarmingly, escalating patterns of abuse. Because our egalitarian and hierarchical groups consist of good and at least

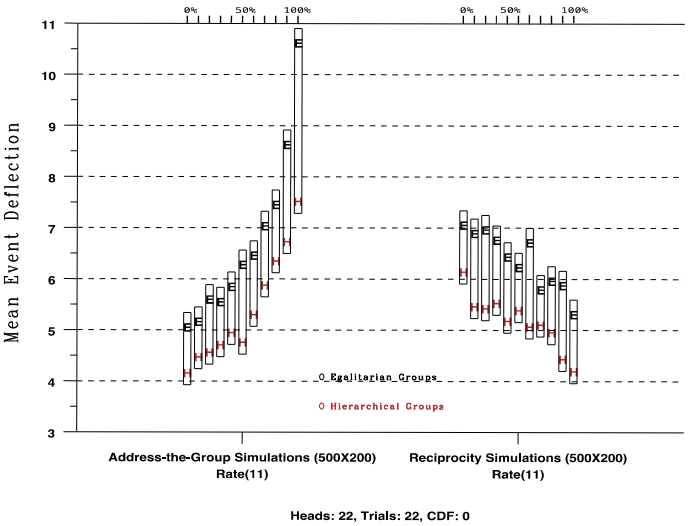


**Fig. 14.2** Predicted event deflection for egalitarian and hierarchical groups controlling for different address-the-group rates and reciprocity rates (22 Binomial Trials)

moderately potent identities, the majority of behaviors even at high rates of reciprocity are positive socio-emotive and active task behaviors in the simulations presented here.

**Identity Maintenance**: We next analyze Group Simulator's predictions about the level of deflection experienced by the group to establish the link between the patterns we observed in Fig. 14.1 and the symbolic identity-maintenance processes that generated them. We focus on deflection because deflection minimization is the driving mechanism behind Group Simulator's predictions. Recall that deflection arises from the discrepancy between our expectations of a situation and our impressions of it.

Figure 14.2 compares egalitarian and hierarchical groups with respect to the mean event deflection experienced by group members. Event deflection is a measure of the tension generated by an event such as the boss addressing the group. The figure compares simulation experiments where we varied the address-the-group rate to experiments where we varied the reciprocity rate. The blocks in the figure indicate each unique combination of factors (the mean deflection experienced in each group type at each rate over 500 turns in 200 simulations). The group means are indicated by the letters H and E for hierarchical and egalitarian groups respectively. For example, the mean deflection of groups where no one addresses the group is 4.2 for hierarchical groups and 5.1 for egalitarian ones. The block lengths, thus, indicate effect size, with larger blocks indicating a greater difference between the groups. The pattern across the blocks is also meaningful. Treating each block as its own experiment, we find that in all 22 simulations egalitarian groups experienced more deflection than hierarchical ones, making it highly improbable that this effect is due to chance.

We find that the address-the-group rate influences deflection, but that the reciprocity rate diminishes this effect. Egalitarian groups experience more deflection because it is more deflecting to be acted upon by an equally potent person than by a more potent one. Increasing the address-the-group rate generates deflection by ensuring that a higher percentage of actions will be addressed towards the group rather than some other object, even if another object would better minimize the agent's deflection. A norm to address-the-group, however, also breaks negative action sequences by providing a new more positively evaluated object of interaction. Nevertheless, the increasing level of deflection as the address-the-group rate increases suggests that a strong norm to address the group is likely to result in accumulating levels of deflection that addressing the group cannot resolve. Higher reciprocity rates weaken the effect of the address-the-group rate because fewer of the actions are directed towards the group, and more actions are addressed towards the agents' last interaction partner which often is the agent that most minimizes the actor's deflection.

Lower group-level event deflection; however, does not necessarily mean that agents in hierarchical groups are all experiencing less deflection, just that most of the group most of time is experiencing less deflection. We next examine patterns at the agent-level to get a better sense of how the agent's role identities influence the level of tension they experience.

Figure 14.3 compares the level of deflection experienced by actors and object-persons in egalitarian and hierarchical groups. The x-axis indicates the percentage of behaviors either addressed to the group (the top panels) or reciprocated (the bottom panels) in egalitarian and hierarchical groups (the left and right panels respectively). The y-axis indicates the median level of deflection experienced by each group member. The solid lines indicate when agents are actors; the dashed lines when they are object-persons.[1]

We find that object persons experience more deflection than actors in both egalitarian and hierarchical groups. We also find that role differentiation leads to different outcomes. Bosses when actors, but particularly when object-persons, experience more deflection than clients or men. Although the agent traces in hierarchical groups are generally more closely grouped and lower than those in the egalitarian groups, bosses when the object of an interaction experience far more deflection than agents in other roles and settings.

These patterns arise from interaction norms encoded in affect control theory's interaction effects. Expectations regarding how we should be treated given our role's evaluation and potency govern the exercise of power in groups. The expectation that people will act in ways that are attuned to the potency of the person with whom they are interacting is an important interaction norm in groups. Good people are not bullies. There is also a strong expectation that powerful people will act in powerful ways. Although being the object of an interaction generally results in a loss of perceived potency, this loss is less if the actor plays an important role in the group. ACT researchers have identified these norms and others, evident as interaction terms in the

[1]The object-person agent traces end at 90% in the address-the-group rate experiments because at a 100% address-the-group rate all actions are directed at the group rather than to the agents.

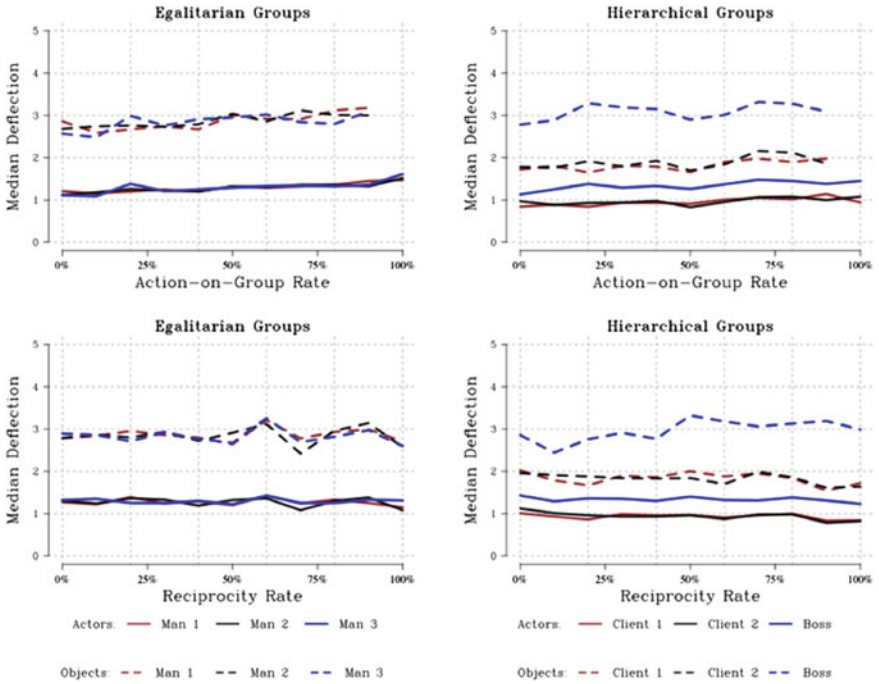


**Fig. 14.3** Predicted median group member deflection as the percentage of actions addressed to the group and reciprocity change when being actors and object-persons

theory's impression change equations, repeatedly in empirical studies of impression formation [5, 38].

These cultural expectations largely explain observed differences in the level of deflection experienced by actors and object-persons in egalitarian versus hierarchical groups. Greater potency comes with greater risk of deflection. Bosses must not only act in powerful ways leading to a loss in potency when they are the object but also in legitimate ones leading to losses in evaluation when they are the actor. The moderating influence of the actor's potency also largely explains why agents in egalitarian groups experience more deflection under most conditions. Our simulated men experience slightly more deflection from acting in dominant ways towards peers, and significantly more deflection from being acted upon in a dominant way.

## Discussion

Our simulations demonstrate how role configurations and relational norms influence group behavior by setting role expectations and moderating the extent to which group members can affirm their roles. We find that hierarchical groups tend to experience

less event deflection, but that actors in dominant roles are likely to experience more deflection than others because they confront more complicated norms pertaining to the exercise of their power. In addition, we find that relational norms allow group members to efficiently resolve deflection through reciprocation, while also allowing them to disrupt sequences of disconfirming behaviors by addressing the group or another group member. These norms are likely to be particularly important in egalitarian groups where there are no clear role expectations establishing dominance patterns.

It is important to note that although there is decades worth of research examining the operation and maintenance of status hierarchies [39], there are far fewer generative models of these dynamics [40], and no other model to our knowledge that applies an identity maintenance perspective. This work highlights two avenues of future research. First, although hierarchical groups may make interactions more predictable, they do not necessarily make them more fulfilling. Preliminary simulation results indicate that, in many instances, people experience more negative emotions in hierarchical groups, suggesting new questions regarding the relationship between identity maintenance and emotion in groups. Second, although promising, affect control theory's emphasis on interaction at the dyadic level limits its ability to model groups. The theory predicts how people respond to being the actor or object-person in an event but not an observer. This has implications for our findings, especially our reciprocity findings, because while these findings likely reflect the state of the agents acting and reciprocating, we have no predictions about the state of the other agents, and thus of the group as a whole. Consequently, a more robust application of the theory will need to consider the deflection experienced by actors and object-persons as well as observers.

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