Power struggles and gender discrimination in the workplace

M. Alperen Yasar*

Department of Economics,
Ca' Foscari University; and
Department of Applied Mathematics,
Paris I Pantheon-Sorbonne University

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Abstract

This study explores the impact of power struggles on the emergence of gender discrimination within the organizational culture. Utilizing an agent-based model, we simulate power struggles as an asymmetric hawk and dove game where agents may categorize their opponents based on their observable traits to make effective decisions. Our model includes two categories: prestigious education and sex, with prestigious education having higher struggling power. We examine three categorization strategies: fine-grained, regular-grained, and coarse-grained categorization. Our results indicate that fine-grained categorizers gain an advantage when the cost of fighting is low. In contrast, coarse-grained categorizers become more peaceful, leading to an advantage when the cost of fighting is high. Our simulation reveals that although there is no meaningful difference between sexes, different behaviors emerge when fine-categorizing agents dominate.

Keywords— power struggles, categorization, gender discrimination, asymmetric hawk and dove games, agent-based modelling, organizational culture

1 Introduction

Interpersonal conflicts are common occurrences in organizations, due to limited resources such as personnel, funding, information, or prestige. Power struggles often arise when individuals perceive social power as a zero-sum game, where one person's gain is considered another person's loss (Greer et al., 2017). The negative impacts of these struggles can be seen in team performance, organizational culture, and structure (Kang, 2022). Understanding the dynamics of power struggles can provide valuable insights into how conflicts arise and how they can be resolved. The present study aims to analyze the impact of power struggles on organizational culture, focusing on the emergence of gender discrimination.

The presence of a difference in power between conflicting parties, formal or informal, can impact the dynamics of a power struggle (Yu et al., 2022). Take, for example, two managers who dispute which idea is superior. The exchange of ideas between them may result in an improved outcome, but the clash of opinions can also lead to a destructive, dysfunctional discussion (De Laat, 1994). If one manager holds a significantly higher position in the organizational hierarchy, then the power imbalance may prompt the other to concede, ending the power struggle without further conflict.

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However, the informal power hierarchy within the team can be subjective. A male worker may believe himself to be superior to a female worker due to his sexist biases, and other male team members may also come to the same conclusion after witnessing the power struggle. This can lead to a culture of discrimination within the organization, where male workers engage in power struggles, specifically against female workers. Newcomers to the organization may adopt this culture or opt to leave, and female employees will face discriminatory behavior that hinders their performance. Over time, this culture can form stereotypes, as categorization and stereotyping are natural outcomes of the categorization process (Taylor et al., 1978).

We create an agent model where agents categorize each other in a random-matching series of asymmetric hawk and dove games. In an asymmetric power struggle, the probability of winning during the contest is determined by the power difference between workers. There are two traits an agent can have: a prestigious education, which increases the struggling power of agents, and sex, which is void of any effect.[1] However, agents do not know the true model. Instead, they apply categorization to make better decisions. A fine-grained categorizer stores data based on every observable trait, while a coarse-grained categorizer stores data ignoring all traits; finally, a regular-grained categorizer only stores information about the education of their opponent. Agents randomly engage in power struggles and imitate others' categorization strategies if they perform better overall. Our main results state that the cost of fighting determines the prevalent categorization strategy. Furthermore, we show that even when sex carries no importance for power struggles, a cultural difference between genders emerges when fine categorization is advantageous.

The purpose of this study is to examine the relationship between employees' categorization strategies and the dynamics of power struggles within an organization.[2] We know of no other work studying heterogeneous power conflicts; instead, previous research has approached power struggles as homogeneous and evaluated their impact as either positive (Bornstein, 2003) or negative (Kang, 2022). Our research offers a more nuanced view by exploring different outcomes of power struggles, considering the interaction between various types of employees, and evaluating the influence of organizational factors such as turnover rate. By doing so, we aim to contribute to a better understanding of power struggles in organizations and the role that categorization strategies play in shaping their nature.

We first provide a succinct overview of the current state of research in the areas of power struggles, categorization, and agent-based modeling. Next, we delve into the subject of power struggles by examining the asymmetric hawk and dove games and identifying the best responses for agents. We then outline the concept of categorization and examine different categorization strategies. Finally, we present the results of our simulations and draw conclusions based on our findings.

2 Literature review

This paper is situated at the intersection of several established fields of research. Our primary focus is the examination of categorization processes and the impact of these on intergenerational culture within the context of power struggles. To our knowledge, Gibbons et al. (2021) was the first to establish a connection between organizational culture, performance, and categorization. However, our definition of the categorization differs slightly, as our agents categorize other agents rather than payoffs. In this literature review, we begin by exploring the concept of power struggles and their influence on organizational performance. Then, we delve into the cognitive process of categorization. Finally, we provide a rationale for using an evolutionary agent-based model to analyze our research question.

2.1 Power struggles and the organization

Power differences exist among individuals, where some have more control over others. Magee and Galinsky (2008) has extensively studied social hierarchy and its relation to social power. Power struggles have been studied in a variety of settings, such as governments (Caselli, 2006), research teams (Kang, 2022), and schools (Twemlow et al., 2001). Pondy (1967) has developed a comprehensive framework for understanding organizational conflicts.

[1] Oakley (2016) differentiates between the terms *sex* and *gender*. While sex refers to a biological distinction, gender is a cultural concept. We use these terms relatively interchangeable in our study, because agents observe sexes, but the result is the emergence of genders.

[2] Not every conflict is a power struggle, but some are actually workspace bullying. The distinction is tricky, and Baillien et al. (2017) creates a very detailed distinction between the two. For the scope of this paper, every conflict is considered a power struggle.

One joint discussion in the literature on power struggles is the correlation between power struggles and organizational performance. The two most relevant areas of this discussion are worker well-being and organizational performance. The former highlights the effects of having more power. Of course, it is easy to understand why individuals are better off from having more power (see Galinsky et al. (2015) for a detailed literature review on the definition and analysis of power). Lammers et al. (2013) presents data that shows that agents with more social power present themselves better than those with less power; hence, they perform better in interviews. Kifer et al. (2013) analyzes the well-being of high-power individuals in the workplace and finds that power indeed increases happiness, contrary to the common misconception about a sad bully who sits on top of the power chain.

The latter, however, needs to be clarified. First of all, it is possible that a power struggle against an outsider could cause unification inside an organization (Stein, 1976). For example, Bornstein (2003) shows that an in-group-out-group bias reduces intra-team free-riding. Furthermore, Simons and Peterson (2000) claims that struggles due to task conflicts between members who trust each other can increase group performance. On the other hand, De Dreu and Weingart (2003) provides data about how conflicts negatively affect performance. Greer et al. (2017) shows that any power hierarchy may benefit individuals but eventually damage group performance. A power struggle between two teams can cause members of teams to feel insecure about their future and promote intra-team power struggles (see Van Bunderen et al. (2018) for an experiment about how power struggles can have spillovers). There are also management decisions that can trigger power struggles. For example, a performance-based employee ranking system can cause employees to struggle for higher rankings, eventually decreasing the overall performance of teams (Ewenstein et al., 2016).

2.2 Categorization

Categorization is a very natural behavior that can be observed in many situations. Koriat and Sorka (2017) suggest that we use cues to associate an entity with another entity we encountered. Erickson and Kruschke (1998) explain how agents have descriptional rules about categories, which help them develop rules of thumbs to use in most situations. Chi (2009) claims that people categorize entities or processes to understand them better; it is easier to both understand and teach when we divide a topic into subtopics. Fiske (1993)'s experiment shows that people tend to finely categorize individuals who hold more power than them and coarsely categorize others. This result is because people want to understand how to become like individuals from higher hierarchies, while they do not care as much for the people they consider below them. Fryer and Jackson (2008) suggest that agents categorize less frequent objects more coarsely, which causes them to lose accuracy in their predictions.

This paper follows Gibbons et al. (2021) by examining the connection between categorization, performance, and organizational culture. Our definition of categorization comes from Taylor et al. (1978), where agents categorize other agents. We try to understand how gender discrimination can emerge from categorization. Previous studies, such as Martell et al. (2012), have shown the emergence of gender segregation through an agent-based model using a spatial approach inspired by Schelling (1978). In contrast, this paper uses an evolutionary game model and is unique because it doesn't incorporate any initial bias against female workers, unlike the aforementioned study. Our findings demonstrate that any bias towards a particular category is solely a result of categorization.

Discrimination's existence in academia, corporate, and politics is now very well documented (see Bertrand and Duflo (2017) for literature review on field experiments of discrimination). Gender, race, or political opinions are typical discrimination topics. A recent paper has demonstrated that only 10% of board members consist of females (Brodmann et al., 2022). Martell et al. (2012) suggests that this ratio could be due to board members' impression of female workers' skills, which could pressure female workers even more. They then create new promoting policies to reduce discrimination based on gender in organizations. Bruner (2019) shows how being classified as a minority can decrease the payoff of a group by using replicator dynamics. Stewart and Raihani (2023), on the other hand, develop a model where stereotypes evolve.

Categorization in game theory has been inspired by the concept of analogy classes developed by Jehiel (2005). Azrieli (2009) presents a model where agents categorize others in a large game, while Azrieli (2010) builds a model where agents categorize others in a series of games where agents randomly match each other. While Mohlin (2014) studies the optimal categorization, Daskalova and Vriend (2020) studies how categorization strategies become shared. Learning how a category behaves on average also requires cognition costs. Mengel (2012) shows that these cognition costs can cause a deviation from strict Nash equilibria over time. Grimm and Mengel (2012)'s experiments show that agents use the finest categorization available to them.

2.3 Evolutionary game theory and agent-based modelling

People observe others to obtain information about how they behave and how well they are doing. Evolutionary game theory is used to show how organizational culture might emerge from simple behaviors (Newton et al., 2019). The advantage of evolutionary models is that they show emerging macrobehaviors from simple heuristics in a very concise and effective way (see Newton (2018) for a detailed literature review on recent studies of evolutionary game theory). Agent-based modelling has been practical in implementing complex agents with memories while loyal to theory (Adami et al., 2016). We follow the literature on evolutionary agent-based models in this paper.

Evolutionary models have seen a resurgence in the last two decades (Newton, 2018). Trust-building processes (Fujiwara-Greve et al., 2012), Kantian morality (Alger & Weibull, 2016), and assortative mating (De Cara et al., 2008) are some of the behavioral topics that have been studied under evolutionary game theory. Moreover, organization science also is studied under evolutionary models. Xiao et al. (2021) use an evolutionary approach to find the determinants of R&D development. Alós-Ferrer and Shi (2012) study asset markets under evolutionary stability. Moreover, computational models have been gaining popularity in organizational studies in the last few decades (Carley, 2002) (see Wall (2016) for an extensive literature review on agent-based models in managerial sciences).

Schelling (1978) showed that in order to observe macrobehaviors, extremely complicated micro behaviors are not necessary. Instead, modelling heuristic-based simple agents with fundamental motives can be enough to reveal very rich results. Crowley (2001) shows that the stability of a model can be explained better when agents have memories, which is more challenging to do in equation-based models. We create an agent-based model to analyze the evolution of organizational culture using a similar framework to Amadae and Watts (2022). Evolutionary agent-based models allow us to explore the emergence of cultures (O'Connor, 2017). O'Connor (2017) state that one of the main advantages of agent-based models is that they do not have to model the interaction between all strategies. Hence, multiple strategies with heterogeneous agents can be conveniently implemented. Furthermore, interactions can be much more complex in agent-based models (Kallens et al., 2018). Another reason for the popularity of agent-based models is the decreasing cost of computational power, as the technology allows scholars to develop more complex models.

3 Power struggles as hawk-dove games

The power struggle dynamics can be compared to those of an asymmetric hawk-dove game. When two managers engage in a power struggle and seek a resolution, the outcome can impact their social prestige. If they reach a mutually agreeable solution, both managers will share the social prestige. On the other hand, if one manager chooses to concede, the other will gain prestige, while the conceding manager will receive nothing. If neither of them concedes, then the winner of the conflict will enhance their social status while the losing manager's power will be damaged. Hawk-dove games are commonly used for conflicts over limited resources. A symmetrical representation of such a game is illustrated in Table 1.

		Player 2: Hawk	Player 2: Dove
Player 1	H	$(V-C)/2, (V-C)/2$	$V, 0$
	D	$0, V$	$V/2, V/2$

Table 1: A generic hawk and dove game, where V is the prize and C is the fighting cost

In a symmetrical hawk-dove game, if the reward is greater than the cost of fighting ($V > C$), then being aggressive, or playing "hawk" (H), is the only Nash Equilibrium (NE) for both players. However, if the reward is less than the cost of fighting ($V < C$), there are two pure strategy NE (H, D) and (D, H) and one mixed strategy NE (MSNE). The MSNE involves playing "hawk" with a probability of V/C and "dove" with a probability of $(1 - \frac{V}{C})$.

The asymmetry in power levels between players in power struggles makes applying the symmetric version of the hawk-dove game difficult. To better represent the dynamics of power struggles, we adopt the asymmetric version of the game presented by Mesterton-Gibbons (1994). In this model, the outcome of a hawk-hawk confrontation is not equal for both players and depends on their power differences. In Table 2, $\theta_{i,j}$ refers to the winning probability of an agent i against an agent j, where $0 \leq x_i \leq 1$ denotes the struggling power of agent i.

	H	D
H	$\theta_{i,j}V - (1 - \theta_{i,j})C$	V
D	0	$V/2$

Table 2: An asymmetric hawk and dove game with row player's payoffs, where $\theta_{i,j}$ indicates the probability of winning for an agent i against an agent j

Following Doi and Nakamaru (2018), we calculate the winning probability of an agent i against an opponent j using Equation 1:

$$\theta_{i,j} = \frac{1}{1 + e^{-(x_i - x_j)*\zeta}} \tag{1}$$

The asymmetric hawk-dove game we use considers that players in a power struggle often have differing levels of strength, information, or prestige. In this version of the game, winning probabilities are not equal for players in a hawk-hawk escalation scenario and instead are dependent on the power difference between players. The power reliability parameter, ζ, represents how much a player can rely on their strength, ensuring that a minimal difference in struggling power does not solely determine the outcome of a struggle. As ζ increases, the probability of winning for the stronger player approaches 1 even with a minimal difference in struggling power, while as ζ approaches 0, both players' winning probabilities approach one-half even with a significant difference in struggling power.

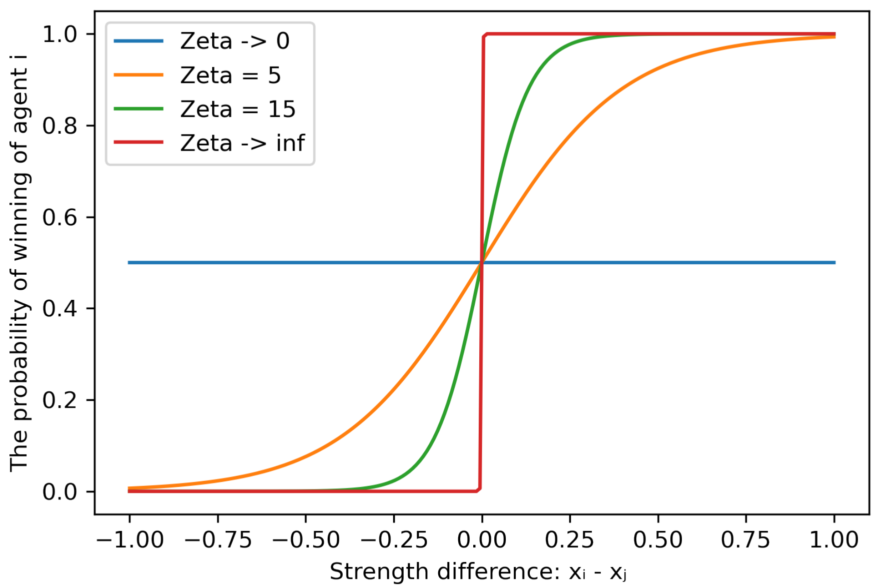


Figure 3: The effect of reliability parameter on the outcome of a hawk-hawk escalation

According to Smith and Parker (1976), if agents possess complete information and the outcome of a power struggle is not solely dependent on the difference in struggling power, mixed strategies may not be necessary. Thus, we denote $s_i = \{s_p, s_w\}$ as the set of best responses for an agent i against an opponent j. s_p is the best response of agent i when she believes that she is more powerful than an agent j (hence, $E_i[x_i] \geq E_i[x_j]$), and s_w is the best response of agent i when she believes that she is weaker than her opponent ($E_i[x_i] < E_i[x_j]$). An example of best responses for an agent i is $s_i = \{H, D\}$. This means that agent i will choose to play "hawk" if she believes she is more powerful than her opponent and play "dove" otherwise. Possible best responses are the following:

$$s_i = \begin{cases} \{H,H\} & \text{if } \frac{C}{V} < \frac{1-\theta_{i,j}}{\theta_{i,j}} \\ \{H,D\} & \text{if } \frac{1-\theta_{i,j}}{\theta_{i,j}} \leq \frac{C}{V} < \frac{\theta_{i,j}}{1-\theta_{i,j}} \\ \{D,H\} & \text{if } \frac{\theta_{i,j}}{1-\theta_{i,j}} \leq \frac{C}{V} \end{cases} \tag{2}$$

The first condition states that when the cost of fighting is low, an agent opts for a hawk response regardless of her relative strength compared to her opponent. In contrast, the second condition states that when the cost of fighting is high, the agent only chooses to play hawk if she believes that she is stronger than her opponent and chooses the dove strategy otherwise.

The third condition arises when the cost of fighting is very high. In this scenario, there is an Evolutionarily Stable Strategy (ESS) where the weaker player adopts an aggressive approach and the stronger player steps back. The stronger player cannot take the chance of adopting a hawk strategy due to the possibility of losing the power struggle, given the high cost of fighting. On the other hand, the weaker player has no reason to change her strategy if she is aware that her opponent will retreat. This equilibrium is called paradoxical by (Smith & Parker, 1976). This paper does not use the paradoxical equilibrium; hence, agents will play $\{H, D\}$ if $\frac{1-\theta_{i,j}}{\theta_{i,j}} \leq \frac{C}{V}$. However, we observe that paradoxical equilibrium sometimes emerges due to misbeliefs about categories.

The sigmoid functions in Figure 3 align with the findings of Yu et al. (2022) and demonstrate how conflict can arise from a power struggle when the power difference between players is not too large or too small. When the players' powers are very similar, they should play dove as $V < C$. If one player is clearly stronger than the other, such as a significant power difference, the weaker player will back down, and the struggle will end in a hawk-dove outcome. According to Smith and Parker (1976), any uncertainty about the power difference can increase the chance of a paradoxical equilibrium, which is also the case in our model.

4 Agent-based model

This section focuses on the definition of agents and categorization strategies for our study on power struggles. We aim to examine the effectiveness of different categorization methods used by agents in power struggles. To understand the impact of these strategies, we divide the agents into two categories: one that is meaningful, i.e., agents are classified based on whether they come from a prestigious or non-prestigious school and one that is void of any effect, where agents are categorized as male or female. On average, agents from prestigious schools are expected to have a higher struggling power compared to those from non-prestigious schools. We define this difference by drawing their struggling powers from a Beta distribution with a higher mean. However, gender does not affect the struggling power, as the study aims to analyze any possible emergent behavior between genders.[3].

Regarding categorization strategies, agents have three options. Firstly, they can be coarse-grained categorizers, not considering either education or gender as a factor in power struggles. Secondly, they can be regular categorizers, believing that prestigious education plays a role in power struggles, but gender does not. Finally, they can opt to be fine-grained categorizers, considering both education and gender as important factors.[4] The Table 4 provides a clear picture of the categorization strategies.

In this agent-based model, agents participate in power struggles through asymmetric hawk-dove games with randomly matched opponents. A vital aspect of the model is that agents don't completely understand their chances of winning a

[3]Wood (2015) shows that when there is a population difference between two irrelevant labels, the cost of fighting determines which population is going to prevail. Since we are not interested in this so-called minority effect, our model is initialized with an equal amount of agents from each possible type.

[4]Following Azrieli (2009), we also model agents who do not categorize themselves. This is because the categorization is to estimate the probabilities of winning against an opponent, and an agent does not play against herself. Hence, she does not have any reason to categorize herself.

	Education	Sex	Categorization
Variants	Prestigious, non-prestigious	Female; Male	Coarse; Regular; or Fine
Signal	By regular and fine-categorizer agents	By fine-categorizer agents	Cannot be observed.
Power	Prestigious education will increase power	Sex does not affect struggling power	Categorization strategy does not affect struggling power

Table 4: Agent properties

conflict. Instead, they rely on their previous experiences against different categories of opponents. An agent calculates the probability of winning against a particular category by taking the average of their previous encounters with that group.

For example, a regular categorizer who has fought against highly-educated opponents four times and won three encounters will believe their winning probability against that group to be 75%. They will consider themselves the stronger player if their expected winning probability is higher than 50%. Using Equation 2, this agent will only play hawk if $\frac{0.75}{1-0.75} > \frac{C}{V} \geq \frac{1-0.75}{0.75}$.

On the other hand, a coarse-grained categorizer only considers their overall encounters ignoring specific categories. Agents update their memories after each round, only retaining information on the outcome of hawk-hawk escalations against a particular category, but not the opponent's actions in previous rounds.[5] The reason for this assumption is because agents try to find their possibility of winning against categories in our model, and they are not interested with what would those categories play on average.

Table 5 illustrates two agents with differing categorization strategies facing the same opponent and getting the same outcome. Initially, each agent is endowed with self-confidence, which we model as a prior that is biased toward winning. Thus, the first row consists of ones, indicating that the estimated probability of winning against a category is always set at one at the start. As a result, after their first match, which they lose, they update their belief to $(1+0)/2 = 0.5$. And after their second match, which is a win, they update their belief to $(0.5*2+1)/3 = 0.66$. If any players plays dove, the agent does not update their prior, as no conflict occurs. Notice that the fine-categorizer only updates one column, while the regular categorizer updates both. In the end, despite facing the same opponent and getting the same outcome, both agents now have different beliefs against opponents with a non-prestigious education.

	A regular categorizer				A fine categorizer				Result
Turn	FN	MN	FE	ME	FN	MN	FE	ME	
0	1	1	1	1	1	1	1	1	Beginning with full confidence
1	0.5	0.5	1	1	1	0.5	1	1	Fought against a male opponent with non-prestigious education and lost
2	0.66	0.66	1	1	1	0.5	1	1	Fought against a female opponent with non-prestigious education and won
3	0.66	0.66	1	1	1	0.5	1	1	Male opponent with prestigious education played dove

Table 5: An example update process for a regular categorizer on the left and a fine categorizer on the right. FN indicates the female opponent without a prestigious education, ME indicates a male opponent with a prestigious opponent, and so on.

[5] This is the main difference between this paper and LiCalzi (1995). While both studies show agents who store their experiences as a source of experience into different categories, agents in our model stores the outcomes, while LiCalzi (1995) describes agents who store their opponent's actions.

4.1 Evolutionary algorithm

We implement an evolutionary algorithm to determine the performance of different strategies in different circumstances. Our approach involves creating a co-evolutionary model where education, sex, and categorization strategies evolve dynamically. We separate the evolution of categorization strategies from the evolution of sex and education, as categorization is a mental simplification of a complex environment. An agent can observe and imitate other agents' categorization strategies but not their sex or education. Instead, we implement another evolutionary algorithm for the categories. At each turn, some workers leave the organization due to typical turnover. Then, new workers will be hired based on how well sexes and educations perform in power struggles.[6]

Our co-evolutionary model uses the imitative logit protocol created by Björnerstedt and Weibull (1994) to assess the imitation process. In this protocol, agents can evaluate the categorization strategies of others and decide whether to adopt them based on their performance relative to their own.[7] With this simple approach, we can analyze the advantages of different categorization strategies. Equation 3 expresses the probability of agent i imitating agent j's categorization strategy.

$$P_i(I) = \frac{e^{\pi_i}}{e^{\pi_i} + e^{\pi_j}} \tag{3}$$

For the turnover process, we apply a similar method. The manager examines the average payoffs of each subcategory (e.g., female workers with a prestigious education, male workers with a non-prestigious education) and selects a new worker with a subcategory proportional to the performance of that category. For example, the probability of hiring a female worker with prestigious education ($P_i(fe)$) is expressed in Equation 4, where π_{fe} represents the average payoff of female workers with prestigious education, while π_{mn} represents the average payoff of male workers with non-prestigious education.

$$P_i(fe) = \frac{e^{\pi_{fe}}}{e^{\pi_{fe}} + e^{\pi_{fn}} + e^{\pi_{me}} + e^{\pi_{mn}}} \tag{4}$$

In summary, the co-evolutionary algorithm has the following key elements:

- Agents with varying educations, sexes, and categorization strategies.
- An imitation protocol for agents to evaluate their categorization strategies.
- A turnover process to observe the evolution of education levels and sexes.

Equations 3 and 4 provide well-defined functions for our co-evolutionary algorithm to choose traits, ensuring robust results. We also checked the robustness of our evolutionary algorithm by using another turnover process where the manager evaluated education and sex separately but found no significant differences.

4.2 Simulation settings

In agent-based modelling, it is common practice to run the simulation multiple times and take the average to ensure robustness against stochasticity. Running the simulation 1000 times ensures that the results are robust to initial stochasticity. Each run consists of 5000 consecutive turns, where we realize that the results do not change afterward. In Algorithm 1, we present a pseudo-code about how each turn works. [8]

[6] This is an evolutionary model called Moran birth and death process, created by Moran (1958). One can also cause retiring agents to be based on their performance; however, this is equivalent to doubling the turnover rate.

[7] We tested our model with the unconditional imitation protocol developed by Roca et al. (2009). Our results showed that the imitative logit protocol creates smoother transitions than the unconditional imitation protocol, which causes cascading categorization strategies. Furthermore, both protocols produce similar results regarding categorization ratios and gender discrimination.

[8] Click here to access the current version of the code.

Algorithm 1 A description of the simulation

```
for Every time step do
    Match agents randomly
    for Every pair of agents do
        Players estimate their probability of winning via their memories
        Players choose their best responses via Eq. 2
        if Both players play hawk then
            Winners calculated via true struggling powers
            Players update their histories
        else
            No update happens
        end if
    end for
    for Every agent do
        Look at a random opponent and imitate via Eq. 3
    end for
    A proportion of agents leave the organization.
    New employees are selected according to how sexes and education levels perform via Eq. 4
end for
```

Since our evolutionary model does not permit complete domination (we use the terminology of Traulsen and Hauert (2009) for domination here, where one strategy completely dominates the population), we analyze the average population per run instead of counting the categories who dominated the simulation.[9] We start the simulation with every trait equally distributed in the population. We set the value of the prize to 10, and we only change the cost of fighting between runs, following Amadae and Watts (2022). The reason we calibrated reliability parameter ζ to 10 is that a higher value will cause power struggles to be almost always won by the stronger side. In comparison, a smaller value will cause the power struggles to be redundant.[10]

Parameter	Value range	Description
T	5000	Number of turns per run
R	1000	Number of runs per parameter combination
N	300	Number of agents per run
V	10	Value of reward
C	$\{20, 80\}$	Cost of losing a fight
ζ	10	Reliability parameter
α, β	(4, 12)	Beta distribution parameters
M	0.01	Turnover rate
ϵ	0.001	Noise

Table 6: Parameters of the simulation.

Another significant factor that we have considered is the rate of personnel turnover. Our findings indicate that a higher turnover rate hinders the formation of organizational culture, while a lower rate may not allow for sufficient observation of the evolution of gender-based behavioral differences. However, we have evaluated the robustness of our main results under varying turnover rates. While substantial changes in turnover rate disrupt the ability to observe any impact on the model or lead to excessively lengthy simulations, minor modifications do not affect our main

[9]The reason behind our evolutionary algorithm not allowing complete domination is due to the complexity of the environment we define. As Wilensky and Reisman (2006) show, environmental complexity usually provides co-existence and prevents complete domination.

[10]Our main result about gender discrimination is robust to the changes in the reliability parameter. However, we observe that a very high reliability parameter helps fine categorization while a very low reliability parameter helps coarse categorization strategies.

conclusions. Additionally, we have incorporated a minimal probability of noise in communication, where an agent will play hawk irrespective of her struggling power. The inclusion of this noise is based on the premise that human decision-making is often prone to error, as noted by Kahneman et al. (2021). Noise introduces a level of randomness that can trigger conflicts even if not initially desired by any of the agents. Furthermore, a mutation rate makes the model more resilient to homogeneous states (Fudenberg & Imhof, 2006).

5 Results

We explore two research questions. Firstly, we assess the efficacy of various categorization strategies. Secondly, we examine the emergence of any gender-related differences. Despite giving agents with prestigious educations a head start, we do not anticipate a gender gap as both genders start on equal footing. Any observed disparity between genders would therefore be considered an emergent behavior.

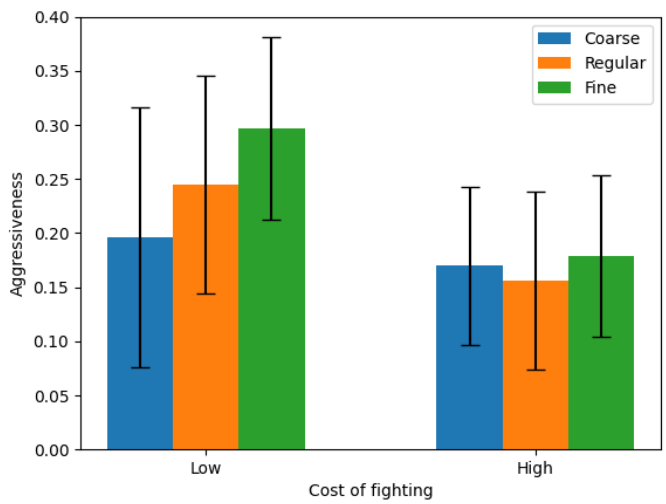


Figure 7: The difference in aggressiveness between categorization strategies. A low cost of fighting indicates that $\frac{C}{V} = 2$, while a high cost of fighting indicates $\frac{C}{V} = 8$. Error bars indicate standard deviations.

In Figure 7, each bar indicates the level of aggressiveness reached by the average of a categorization strategy. For example, the leftmost bar shows that coarse categorizers played hawk 20% of the time on average when the cost of fighting is 20. Our results reveal that finer-grained categorization strategies lead to increased aggressiveness among agents when the cost of fighting is low. This result is statistically significant, with a $p < 0.01$ value for consecutive bars. It's important to keep in mind that the error bars represent standard deviations. The reason for this trend can be easily explained using a simple example. If we consider a population of agents with varying levels of education, the overall power of the population will be in between the two groups, as shown in Figure 8. Looking at Table 5 highlights that fine categorization leads to exploring against a greater number of opponents, which becomes advantageous when the cost of conflict is low. This finding aligns with the study by Martignoni et al. (2016) that found that over-specification can lead to exploratory effects.

The aggressiveness difference between regular and coarse categorization is tricky. A coarse categorizer eventually evaluates herself against the average of the whole population. In contrast, a regular categorizer evaluates her power against two averages: opponents with non-prestigious education and prestigious education. Since the prior is always lower, a regular categorizer might use this fact to her advantage. Figure 8 visualizes this example.

5.1 Cost of fighting

In our simulations, we observed a correlation between the cost of fighting and the prevalence of different categorization strategies. When the cost of fighting was low, we saw a rise in the use of fine categorization, while when the cost

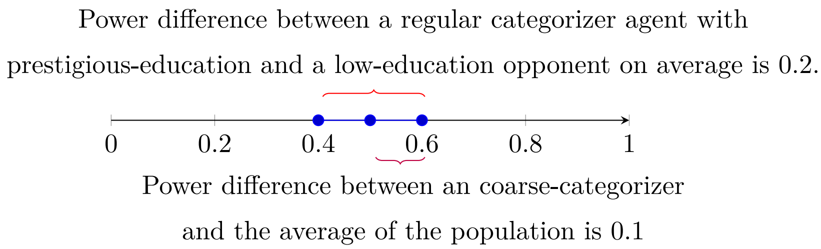
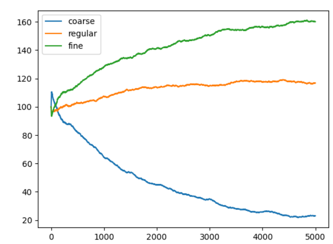
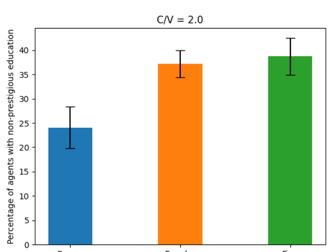


Figure 8: Coarse-categorizer agents tend to weigh their struggling power against the average population, as they do not distinguish between categories.

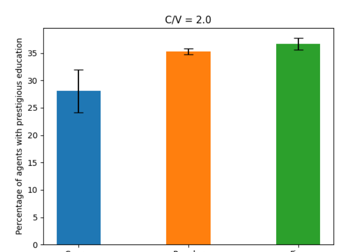
of fighting was high, we observed an increase in coarse categorization. As our game is an asymmetric hawk and dove game, the cost of fighting must always be greater than the prize. To explore this relationship, we conducted simulations with the cost of fighting starting from 11, and found that values above 100 produced similar results. For the purpose of our analysis, we defined low cost as 20 and high cost as 80.



(a) Average simulation results when the cost of fighting is low.



(b) Non-prestigious education



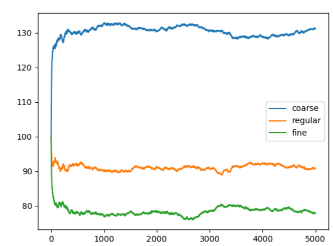
(c) Prestigious education

Figure 9: Figure 9a shows the average time series when $C/V = 2$. Figures 9b and 9c show the overall categorization strategies per education type. Error bars indicate standard deviations.

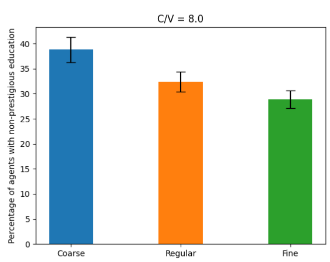
Figure 9 depicts the average of a thousand runs where the cost of fighting is relatively low ($C/V = 2$). We observe that fine categorization enjoys a very sharp advantage against other categorization strategies. The fact that fine-categorizer agents prevail against regular-categorizing agents when the cost of fighting is low is intriguing. Even though we know that different sexes have the same struggling power, they may not have the same aggressiveness level throughout the simulation. The reasoning is that, initially, fine-categorizer agents may increase in one sex while it decreases in the other only because of stochasticity. Since coarse-categorizer agents tend to see the average population, they estimate that the struggling power difference between their opponent and them is relatively small, as explained in Figure 8. Therefore, they tend to employ a more pacifist strategy. Fine-categorizer agents can become more aggressive even against stronger opponents due to not being punished. This is the emergence of paradoxical equilibrium explained in Section 3. Suppose fine-categorizer agents realize that female agents with prestigious education becomes coarse-categorizers on average and play dove as coarse-categorizer agents more frequently do. In that case, fine-categorizer low-education agents may exploit this fact via paradoxical equilibrium. This causes female workers with prestigious education to leave the organization over time, causing only male workers with education to stay in the workplace. Even though we do not ensure differences between sexes, cultural differences emerge.

Furthermore, we observe that both education types follow a similar categorization strategy. However, agents with prestigious education perform better if they choose to be coarse-categorizers than agents with non-prestigious education. This is also expected because they have more struggling power on average. Also, this is why we did not focus on the population difference between education types, as any difference in this regard is solely a result of our assumptions and not an emergent behavior from the model. Nevertheless, categorization choices by agents of different education types remains intriguing. Most importantly, these results are the average of a thousand runs. Hence, this pattern indeed is consistent through different parameter settings or initial conditions.

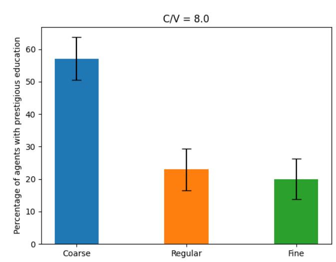
When we increase the cost of fighting in Figure 10, we observe that coarse-categorizing agents obtain an evolutionary advantage in the simulation more than regular or fine-categorizer agents when the cost of fighting is high. This is because they calculate the average of the population; therefore, coarse-categorizer agents tend to reach a peaceful conclusion much faster, providing an evolutionary advantage. On the other hand, regular and fine-categorizer agents may try being aggressive for longer since they will not be punished against peaceful opponents, as explained in Table 5. However, when they are punished, the cost of being punished can be too high to slow them down in the evolutionary race. More interestingly, agents of a prestigious education now mainly select to be coarse-categorizers.



(a) Average simulation results when the cost of fighting is high.



(b) Non-prestigious education



(c) Prestigious education

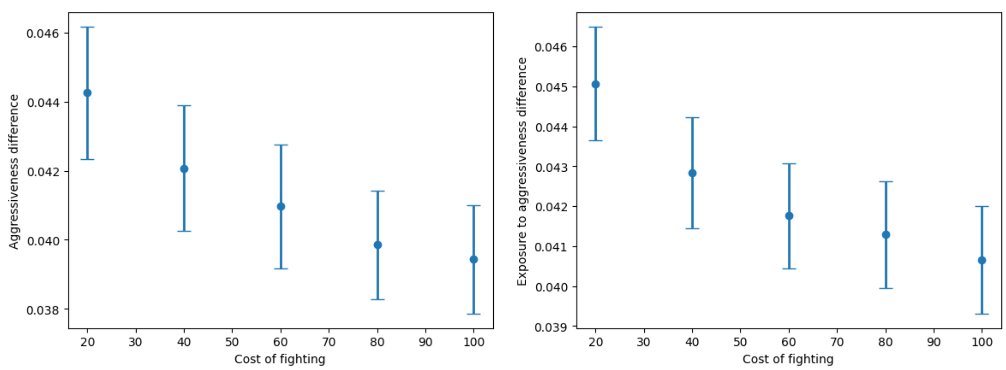
Figure 10: Figure 10a shows the average time series when $C/V = 8$. Figures 10b and 10c show the overall categorization strategies per education type. Error bars indicate standard deviations.

5.2 Gender discrimination

In our second analysis, we examine the disparities between the two genders. However, a direct comparison between the two is not feasible for several reasons. Firstly, there is no intrinsic difference between the genders as both are modeled similarly with identical initial conditions and the same capacity for struggle. Any variation observed is solely the result of randomness. Hence, if a single simulation were to depict a difference between the genders, it would likely be an artifact of chance rather than a meaningful insight. Averaging multiple simulations is also not an appropriate method, as the stochastic nature of the model would result in equal chances of either gender prevailing, meaning that differences will cancel each other out after numerous simulations. To address this issue, we adopt a different identification strategy, considering the absolute difference between the cardinalities of genders as a meaningful metric.

In Figure 11a we observe the emergence of gender differentiation for different costs of fighting. Aggressiveness here represents the percentage of the "hawk" strategy being played by the gender. We should note that the coefficient of the relationship is trivial because we could divide the cost of fighting and the value of the prize by 10, and the difference in aggressiveness would stay the same, essentially multiplying the coefficient by a factor of 10. Furthermore, the direction of the relationship stays the same in various parameter combinations.[11] This result is especially striking. Initially, we implement no difference between genders. However, if the cost of fighting is low, a cultural difference between genders emerges. This difference eventually might lead to stereotypes, as explained by Taylor et al. (1978). Furthermore, our results indicate that a newcomer male agent eventually adopts a more aggressive strategy due to the turnover process.

Figure 11b depicts the difference in exposure to aggressiveness between genders, revealing a clear case of gender discrimination. This result goes beyond what was indicated in Figure 11a, which merely pointed to the existence of cultural differences and stereotypes. Figure 11b demonstrates a clear case of discrimination against one gender. The difference in aggressiveness and exposure to aggressiveness represent two distinct issues. The former suggests that agents' behavior will change based on their label, while the latter highlights that an agent will be treated differently simply due to their label as a woman. The reason for this discriminatory effect lies in the nature of the hawk and dove game, where the cost of fighting is always higher than the reward. As a result, a constantly fighting agent will eventually fail unless they battle opponents who always play dove. Thus, a frequently targeted category must play dove, as otherwise, they will lose more than they gain overall. This result aligns with the concept of paradoxical equilibrium.



(a) Aggressiveness

(b) Exposure to aggressiveness

Figure 11: These figures show the differences between genders. Error bars indicate standard deviations. Each consecutive $p < 0.01$, except from 60 to 80.

6 Discussion

We conducted a study of the impact of different categorization strategies on power struggles using agent-based modeling. The results showed that there is not a single categorization strategy that is always optimal, but rather the most advantageous strategy depends on the environment. Nevertheless, choosing the true model for the situation can prevent overall poor performance by an agent.

Power struggles have various effects on organizations. Should a team leader accept the belief that power struggles

[11]For robustness analysis, we follow the framework of Borgonovo et al. (2022). Following this framework, we change imitation strategies, parameters, and an update mechanism one by one, and observe the correlation between the cost of fighting and gender discrimination from Figure 11a. Different imitation protocols change the parameters where categorization strategies prevail; however, the correlation between the difference of genders in aggressiveness and cost of fighting remains in the same direction. Furthermore, different parameters might change the cooperation rate or the winning categorization strategy, yet gender discrimination remains negatively related to the cost of fighting.

indeed increase the team performance, following Simons and Peterson (2000), then she should decrease the cost of fighting while promoting fine categorization among her team members. On the other hand, if she believes that a struggle decreases the team performance for the sake of the agent's social power, then she should increase the cost of fighting while promoting the coarse categorization in the workplace.

Our findings demonstrate that even in the absence of actual differences between genders, gender discrimination can arise as a result of fine categorization. As this categorization method becomes dominant, workers will develop differences that were not previously present in the organization. Male workers will exhibit more aggression towards female workers, while female workers will tend to become increasingly passive in power struggles. This outcome is truly remarkable. If a workplace is observed where male workers are more ambitious and female workers are more hesitant, it may be wrongly assumed that there is indeed a difference between the genders. However, this result is actually the product of a categorization process.

The study by Brooks et al. (2018) highlights the existence of behavioral disparities between people of different castes in India. Our simulation model offers an explanation for how these disparities can arise from power struggles within the populations, resulting in an emergent discriminatory culture. The outcome of these struggles may be influenced by initial randomness and discriminatory agents mistaking differences as significant, rather than assuming an initial distinction in populations, as proposed by Wood (2015) in the context of the minority effect. Thus, it is not necessary to postulate a pre-existing bias in organizational cultures to see differences emerge.

Mills (1988) argues that organizations are the underlying effect of gender discrimination. We claim that discrimination might emerge in any organization due to power struggles, given the low cost of fighting. We provide evidence using agent-based modelling that this is indeed achievable if we adopt the categorization approach of Taylor et al. (1978). Of course, we do not claim that there is no bias against female workers. On the contrary, society has its own bias towards women, which affects organizational culture as well (Kartolo & Kwantes, 2019).

Moreover, we do not argue that the difference in cooperation between sexes has no biological reason. Instead, even without a biological reason, a virtual distinction between two groups of people may lead to a difference in behaviors over time. Finally, we test the gender-blind hiring idea of Martell et al. (2012) in our simulations and find that it does not reduce discrimination against female workers. This is expected since the formation of the culture is due to categorization and power struggles rather than the turnover process. A manager might instead reduce the formation of the culture by reducing power struggles.

7 Conclusion

To summarize, our findings demonstrate that various categorization strategies have differing impacts on power struggles and cooperation levels, depending on the cost of fighting. A fine categorization strategy produces increased aggression, while a coarse-categorized strategy leads to more harmonious outcomes. Moreover, when a fine-grained categorization strategy prevails, it can result in discrimination, even in the absence of meaningful differences between categories.

Our study makes two key contributions to the field of management. Firstly, it provides new insights into power struggles and the interplay between categorization strategies, cooperation levels, and the cost of fighting. This information can be valuable for managers who are looking to reduce or increase power struggles in their organizations. Secondly, we demonstrate that gender discrimination can be modeled and explained through an agent-based approach without prior biases or assumptions. This novel contribution to the literature highlights the usefulness of categorization as a framework for understanding discrimination.

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