Effects of conflict on resistance and cooperation in hierarchical groups



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Abstract

Many social organisms engage in collective actions in which there is a mismatch between individual and common interest. Such problems may include competition with other groups or collaborative efforts to secure resources from the environment. In this thesis I test novel theoretical predictions which see hierarchy as one potential solution to the collective action problem at hand. More specifically, models have shown that high-rank individuals in hierarchical groups are expected to contribute more toward the group's success than low-rank individuals during inter-group conflict. This pattern of contribution by the high-rank group members is expected to increase the group effort of hierarchical groups in comparison to egalitarian groups. However, the increased individual effort of high-rank individuals is expected to reduce their net benefits in comparison to individuals with lower rank.

To study these effects, I devised eight behavioural experiments with more than 2300 participants from three national cultures which operationalized hierarchy in both political and economic terms. In these experiments, I utilized a behavioural game theory paradigm called the contest game, which simulates an inter-group collective action problem in experimental settings. Results from the thesis suggest that in economic hierarchy high-rank players may contribute more than low-rank players, while in political hierarchy this may not be the case. Groups with economic hierarchy exerted less effort than groups without such hierarchy (e.g. egalitarian), mainly due to a reduced contribution of the low-rank players. However, groups with political hierarchy usually exerted more effort than politically egalitarian groups. These findings suggest that the type of hierarchy is important, as it leads to different results in terms of contribution both at the individual and at the group level.

Further to the these questions, I studied the effect of the collective action problem type, gender, and cognitive processing on the contribution preferences of players. Results suggest that usually inter-group conflict is not important for the contribution preferences of players. Furthermore, the gender of participants and the decision making speed were not important factors for their relative contribution as well, neither under political, nor under economic hierarchy.

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Contribution to collaborative efforts

Chapter 2 was prepared in collaboration with my supervisor and Sergey Gavrilets. I did the majority of the work. The remainder of the chapters were prepared by me with feedback from my supervisor.

Contents

Glossary **vii**

1 Introduction **1**

1.1 Conceptual framework . . . 3
1.1.1 Collective action problems . . . 4
1.1.2 Group structure . . . 10
1.2 Empirical framework . . . 14
1.2.1 Evolutionary game theory . . . 14
1.2.2 Behavioural game theory . . . 15
1.3 Models of hierarchy and collective action . . . 22
1.3.1 Review of theoretical work . . . 23
1.3.2 Benefits and costs of hierarchy . . . 26
1.4 Empirical results from behavioural game theory . . . 29
1.4.1 Rank and individual effort . . . 31
1.4.2 Rank and individual benefit . . . 33
1.4.3 System type and group effort . . . 36
1.4.4 Collective action problems and individual effort . . . 38
1.4.5 Gender and individual effort . . . 40
1.4.6 Cognitive processing and individual effort . . . 42
1.5 Overview of research questions . . . 45
1.6 Thesis structure and contributions . . . 46

2 Experiments with economic hierarchy **49**

2.1 Introduction . . . 49
2.2 Study 1 . . . 56
2.2.1 Experiment 1a . . . 57
2.2.2 Experiment 1b . . . 63
2.2.3 Group-level comparison between Experiment 1a and Experiment 1b . . . 66
2.3 Study 2 . . . 68
2.3.1 Experiment 2a . . . 69
2.3.2 Experiment 2b . . . 73

2.3.3 Group-level comparison between Experiment 2a and Experiment 2b . . . 76
2.4 Discussion . . . 78
2.4.1 Findings . . . 78
2.4.2 Conclusions . . . 89

3 Experiments with political hierarchy 91
3.1 Introduction . . . 91
3.2 Study 3 . . . 101
3.2.1 Experiment 3a . . . 102
3.2.2 Experiment 3b . . . 108
3.3 Study 4 . . . 113
3.3.1 Experiment 4a . . . 114
3.3.2 Experiment 4b . . . 124
3.4 Discussion . . . 129
3.4.1 Findings . . . 129
3.4.2 Conclusions . . . 137

4 Meta comparisons 139
4.1 Introduction . . . 139
4.2 Methodology . . . 143
4.3 Results . . . 145
4.3.1 Primary questions . . . 145
4.3.2 Secondary questions . . . 158
4.4 Conclusions . . . 162

5 General discussion 167
5.1 Findings . . . 168
5.1.1 Rank and individual effort . . . 168
5.1.2 Rank and individual benefit . . . 170
5.1.3 System type and group effort . . . 172
5.1.4 Collective action problems and individual effort . . . 175
5.1.5 Collective action problems and resistance . . . 179
5.1.6 Gender and individual effort . . . 180
5.1.7 Cognitive processing and individual effort . . . 182
5.2 General shortcomings and future research . . . 183
5.2.1 Sample and validity . . . 183
5.2.2 Forms of hierarchy and proximate mechanisms . . . 184
5.3 Final remarks . . . 188

Appendices

A Study 1 **193**
A.1 Methods . . . 193
A.2 Analytical framework . . . 196
A.3 Materials for Experiment 1a . . . 198
A.3.1 Instructions . . . 198
A.3.2 Quiz . . . 201
A.3.3 Training round . . . 204
A.3.4 Period information view . . . 204
A.3.5 Decision view . . . 206
A.3.6 Round outcome view . . . 208
A.3.7 Period outcome view . . . 209
A.4 Models for Experiment 1a . . . 210
A.4.1 Contribution model . . . 210
A.4.2 Net benefit model . . . 212
A.5 Materials for Experiment 1b . . . 213
A.5.1 Instructions . . . 213
A.5.2 Quiz . . . 216
A.5.3 Training round . . . 219
A.5.4 Period information view . . . 219
A.5.5 Decision view . . . 220
A.5.6 Round outcome view . . . 222
A.5.7 Period outcome view . . . 222
A.6 Models for Experiment 1b . . . 224
A.6.1 Contribution model . . . 224
A.7 Models for group comparison in Study 1 . . . 225
A.7.1 Contribution model . . . 225

B Study 2 **227**
B.1 Methods . . . 227
B.2 Simulation . . . 230
B.3 Analytical framework . . . 235
B.4 Materials for Experiment 2a . . . 236
B.4.1 Instructions . . . 236
B.4.2 Quiz . . . 242
B.4.3 Round information view . . . 246
B.4.4 Decision view . . . 248
B.5 Models for Experiment 2a . . . 250
B.5.1 Contribution model . . . 250
B.5.2 Expected net benefit model . . . 252
B.6 Materials for Experiment 2b . . . 253

B.6.1 Instructions . . . 253
B.6.2 Quiz . . . 257
B.6.3 Round information view . . . 260
B.6.4 Decision View . . . 262
B.7 Models for Experiment 2b . . . 264
B.7.1 Contribution model . . . 264
B.8 Models for the group comparison in Study 2 . . . 265
B.8.1 Contribution model . . . 265

C Study 3 **267**
C.1 Methods . . . 267
C.2 Analytical framework . . . 271
C.3 Materials for Experiment 3a . . . 272
C.3.1 Instructions . . . 272
C.3.2 Quiz . . . 279
C.3.3 Round information view . . . 282
C.3.4 Decision views . . . 283
C.4 Models for Experiment 3a . . . 286
C.4.1 Contribution model . . . 286
C.4.2 Resistance model . . . 287
C.5 Materials for Experiment 3b . . . 288
C.5.1 Instructions . . . 288
C.5.2 Round information view . . . 295
C.5.3 Decision views . . . 298
C.5.4 Round outcome view . . . 301
C.6 Models for Experiment 3b . . . 303
C.6.1 Contribution model . . . 303
C.6.2 Resistance model . . . 304

D Study 4 **305**
D.1 Methods . . . 305
D.2 Simulation . . . 308
D.3 Analytical framework . . . 312
D.4 Materials for Experiment 4a . . . 313
D.4.1 Instructions . . . 313
D.4.2 Quiz . . . 321
D.4.3 Round information view . . . 324
D.4.4 Decision view . . . 326
D.5 Models for Experiment 4a . . . 330
D.5.1 Contribution model . . . 330

D.5.2 Expected net benefit model 332
D.5.3 Expected adjusted contribution model 334
D.5.4 Resistance model 335
D.6 Materials for Study 4b 337
D.6.1 Instructions 337
D.6.2 Quiz 346
D.6.3 Round information view 348
D.6.4 Decision views 350
D.7 Models for Experiment 4b 355
D.7.1 Contribution model 355
D.7.2 Expected net benefit model 357
D.7.3 Expected adjusted contribution model 358
D.7.4 Resistance model 359
References 359

Glossary

collective action problems . a type of social dilemma, where there is a conflict between individual and collective interest.

"us vs. nature" problems . . collective action problems that include collaborative efforts to secure resources from the environment, such as hunting or migration.

"us vs. them" problems . . . collective action problems which include competition and conflict between groups, such as war.

hierarchical groups . . . . . groups with differences in rank based on a valued social dimension (e.g. resources, dominance, prestige, etc).

egalitarian groups . . . . . groups without such rank differences, e.g. groups with flat hierarchies.

preferences . . . . . ordering of decision-making alternatives, based on their relative utility for the individual.

effort . . . . . the preference of the individual to contribute to the group's success by diminishing his/her expected benefit. In the theoretical and empirical literature various alternative definitions are used to denote effort, such as altruism and cooperation.

contribution . . . . . a proxy measurement of effort in experimental games. In many experiments, people are asked to give part of their monetary resources to increase the chance of their group's success. The amount given is their contribution.

total contribution . . . . . a sum of all individual contribution preferences of players in a group.

resistance . . . . . the preference of the individual to reduce the power of the hierarchy over him/her by diminishing his/her expected benefit.

intuitive preference . . . . . a preference which is mainly driven by the automatic decision-making system. Intuition is usually studied by asking participants to make a decision under time pressure. It is not to be confused with the term "instinctive", which refers to a potential evolutionary origin. Intuitive preferences are usually fast, effortless, and inflexible.

deliberative preference . . . a preference which is mainly driven by the deliberative decision-making system. Deliberation is usually studied by asking participants to think for a pre-defined time period before they can make a decision. Such preferences are usually slower and flexible.

benefit . . . . . how much the individual earns from a strategic situation. In the theoretical and empirical literature the term benefit can be substituted by the terms earning, cost, and payoff. In the evolutionary literature, the term is usually substituted by fitness.

1

Introduction

Humans and other social animals routinely engage in collective action problems over various resources. Collective action problems can be seen as social dilemmas where there is a mismatch between individual and group interest (R. M. Dawes, 1980). When the group has to take action, such as to go to war or to organize a hunting expedition, individuals are facing the question whether they want to take part in it by incurring a cost to themselves for the greater good or to free-ride. Collective action problems can be roughly categorized into two types: "us vs. them" problems and "us vs. nature" problems (Gavrilets, 2014; González-Forero & Gardner, 2018). The "us vs. them" problems include competition and conflict between groups for resources, such as food and mating opportunities. The "us vs. nature" problems include collaborative efforts to secure resources from the environment, such as group migration and foraging. Surprisingly, theoretical and empirical research suggests that humans are likely to cooperate in these circumstances, which has been seen as

a central puzzle in evolutionary biology (Rand & Nowak, 2013). Previously, there have been multiple proposed mechanisms which aim to explain this puzzle, such as true altruism, reciprocity, reputation, internalized social norms, and third-party punishment (McElreath & Boyd, 2007; Nowak, 2006; Richerson & Boyd, 2005; Bowles & Gintis, 2011). In this thesis, I will aim to explore a new additional mechanisms which may help groups solve the collective action problem they are facing — the hierarchy within the group (Gavrilets & Fortunato, 2014; Gavrilets, 2015; Gilby et al., 2015; M. L. Wilson, Kahlenberg, Wells, & Wrangham, 2012; Zhuang, Wang, Fan, & Di, 2012), which can be defined as the rank-differential based on a meaningful characteristic for the evolutionary fitness of individuals, such as resources, political position, strength, prestige, etc. (Magee & Galinsky, 2008).

In other words, the primary objective of this thesis is to examine how human hierarchical groups function during collective action problems.

Chapter structure In this chapter I will briefly outline the conceptual (Section 1.1) and methodological (Section 1.2) frameworks of the thesis. In Section 1.3 I will review recent work regarding the effects of hierarchy on collective action problems. Theoretical predictions from this section will constitute the main research hypotheses of the thesis. They suggest that hierarchical groups may be better able to solve "us vs. them" collective action problems than egalitarian groups. This expectation is mainly driven by the high-rank players in such groups, who are likely to over-contribute and thus suffer significant losses for themselves. In Section 1.4 I will review empirical literature from the field of behavioural game theory, which explores these hypotheses. I will concentrate my effort on results from collective action problem games, such as the public goods game and the contest game. The empirical literature regarding these conclusions is not always unambiguous. Collective action problem games usually demonstrate that high-rank individuals outperform low-rank individuals. However, when hierarchical

and egalitarian groups are compared directly, results are inconclusive — in some cases hierarchical groups fare better, while in other cases the reverse is observed. Furthermore, I will overview several additional questions, which will be asked throughout this thesis. Namely how the type of collective action problem ("us vs. them" vs. "us vs. nature"), the gender of participants (male vs. female), and the decision making speed of each contribution decision (fast vs. slow) will affect the effort of group members solving collective action problems.

1.1 Conceptual framework

The conceptual framework of this thesis is inspired by theoretical thinking derived from work of Sergey Gavrilets and collaborators (Gavrilets & Fortunato, 2014; Gavrilets, 2015, 2014; Perry, Shrestha, Vose, & Gavrilets, 2018). Based on the framework, two factors which may influence the solution of the collective action problem faced by groups are the type of problem and the group's structure. More specifically, this conceptual framework is concentrated on the effects of hierarchy and "us vs. them" collective action problems over individual and group effort of human subjects. I will compare experimentally this effort with control conditions — namely egalitarian group structure and "us vs. nature" collective action problems.

In what follows, I will unpack the types of collective action problems faced by the group and the role of "us vs. them" problems, which include between-group conflict and competition, in human evolution Section 1.1.1. Furthermore, in Section 1.1.2 I will introduce the degree of hierarchy as one potential group structure variable which may be important for the solution of the collective action problem faced by the group. I will unpack what I mean by hierarchy, how this differs from the concept of egalitarianism, and what is the role of hierarchy in human evolution.

1.1.1 Collective action problems

Types of collective action problems

As discussed, collective action problems can be broadly categorized into two types: "us vs. nature" and "us vs. them" (Gavrilets, 2015, 2014; González-Forero & Gardner, 2018). The "us vs. nature" problems include collaborative effort to secure resources from the environment, such as group migration and foraging. The "us vs. them" problems include competition and conflict between groups for resources, such as food and mating opportunities.

Both types of situations are observed in multiple species (González-Forero & Gardner, 2018) and are potentially prevalent in human populations (Gavrilets, 2014).

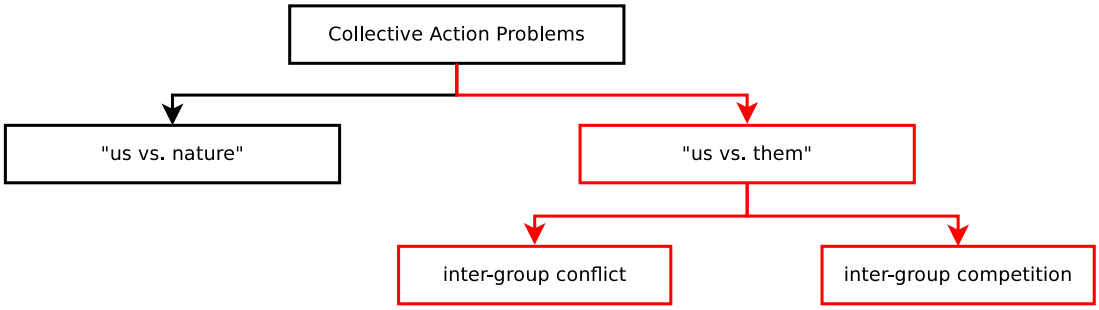


Figure 1.1: Types of collective action problems.

"Us vs. them" problems and human evolution

Before going further, it is important to elaborate on what do I mean by "us vs. nature" collective action problems and how do they differ from the "us vs. them" problems, which are the main emphasis of this thesis. In the presented conceptual framework, the abstract definition of an "us vs. nature" collective action problem is "collective actions that aim to overcome the challenges from nature" (Gavrilets, 2014). Furthermore, Gavrilets has defined "us vs. nature" games in the following way: "The success of a particular group in these activities largely does not depend on the actions of neighbouring groups. I will refer to such collective actions as 'us

versus nature' games.", while "us vs. them" games are defined as "The success of a particular group in an 'us versus them' game definitely depends on the actions of other neighbouring groups." (Gavrilets, 2014).

This definition, although subjective, has merits. The first merit comes from examples provided to illustrate "us vs. nature" collective action problems in the literature, which indeed have one commonality — the fact that the outcome of the strategic situation do not depend on a neighbouring group, but on another species, pure chance, or simply on the accumulated effort of the group members. For example, cases of "us vs. nature" collective action problems include foraging for resources, hunting big game, collective migration, and construction of a building to protect the group from natural phenomenon. It is important to acknowledge that "us vs. nature" collective action problems can be further sub-divided into various categories, for instance categories where the group plays against an unknown probability of an event which is outside of their control (like a natural disasters), or where they "play" against another species (during hunting and foraging).

The second merit of the definition stems from theoretical accounts which posit that "us vs. them" collective action problems are different, at least in the context of human evolutionary history, from "us vs. nature" problems. For example, evolutionary scientists have suggested that humans' unique ability to collaborate and solve collective action has first evolved in the context of group selection and then, through a spill-over effect, have helped us improve our collective effort against natural phenomena (Alexander, Mellars, & Stringer, 1989; D. S. Wilson & Wilson, 2007; Gavrilets, 2015, 2014). Furthermore, as illustrated in this section, indeed there are arguments to believe that "us vs. them" collective action problems are a very important part of human evolution, as seen both in hunter-gatherer societies and in comparative studies.

However, it is important to clarify that in this thesis I will not be able to make concrete inferences about "us vs. nature" problems. As briefly mentioned, such

problems are used as a philosophical opposition, grounded in evolutionary theory, which allowed me to see the effect of "us vs. them" problems on the human psyche. Thus, despite its subjective nature, its usefulness for the operational definitions of the collective action problem types, deployed in the empirical frameworks, is why it is employed as a critical assumption of this thesis.

The "us vs. them" collective action problems are seen as a vital part of human evolutionary history (Alexander et al., 1989; Choi & Bowles, 2007). In conflict situations, especially in groups with strict boundaries, there is little room for free-riding, because the success of the group is based on the total group effort in absolute terms, which makes group-level forces particularly powerful (Gavrilets, 2014). Indeed, multiple theoreticians have used "us vs. them" problems as the "prototypical" collective action problem in order to explain their evolutionary links with mental phenomena, such as empathy, cooperation, and group categorization. For instance, a theoretical tradition within the field of evolutionary biology, known as parochial altruism (Choi & Bowles, 2007; Bowles, 2009), uses multi-level selection theory to explain how organisms have adapted to higher levels of between-group conflict by developing within-group altruism and between-group hostility. Multi-level selection theory posits that some human adaptations may work in order to enhance the general survivability of the group, which, subsequently, influences the evolutionary fitness of individuals within these groups (and the survival of their offspring) (D. S. Wilson & Wilson, 2007). Groups which fail in "us vs. them" collective action problems may perish and produce no offspring or leave offspring which has a high mortality rate (Bowles, 2009). It is a type of gene-centric view of evolution which sees the group as one possible "vehicle" (Dawkins, 2006) for human's selfish genes.

Indeed, results from cross-cultural studies with extant and extinct hunter gatherers, as well as comparative research with chimpanzee societies suggest that conflict can be seen as an important and recurrent force in human evolution, which

may potentially influence our behavioral patterns.

It is a well recognized finding that war is a feature of current and historic human societies, at least since the advent of agriculture (Turchin, Currie, Turner, & Gavrilets, 2013). Based on ethnographic research, hunter-gatherers are seen to exhibit a form of simple inter-group conflict, characterized by raids and ambushes. In such conflicts, individuals are targeted based on their out-group membership, not for personal reasons (Glowacki & Wrangham, 2013). Raiding attacks, especially at night, are the most common form of between-group conflict, and are usually done in a surprise fashion, which often triggers revenge cycles between hostile groups (Gat, 2008).

Lethal aggression has been pinpointed in various ethnographic and archaeological sites, such as the Aboriginal people in Australia (J. Morgan & Buckley, 1852; Kimber, 1990; Tacon & Chippindale, 1994), the ethno-linguistic groups in the north-west coast of America (Drucker, 1965; Maschner, 1997; Gat, 2008), the Amazonian Yanumamo people (Chagnon, 1983), and the Adaman Islanders (Kelly, 2005).

Indeed, to illustrate the distribution of conflict behaviour among hunter-gatherers, I utilized an ethnographic dataset consisting of a sample of 339 hunter-gatherer cultures (Binford, 2001). The dataset encodes more than 100 variables, several of which relate to inter-group conflict. One such variable encodes the scale and type of inter-group violence in four different categories:

- None reported;
- Revenge raiding;
- Accelerative raiding;
- Accelerative conflicts of annihilation.

As illustrated on Figure 1.2, out of the 339 hunter-gatherer groups, this variable was not coded for 6 groups, as there was insufficient information. Out of the remaining

groups, only 73 (21.92%) did not exhibit any form of raiding behaviour.

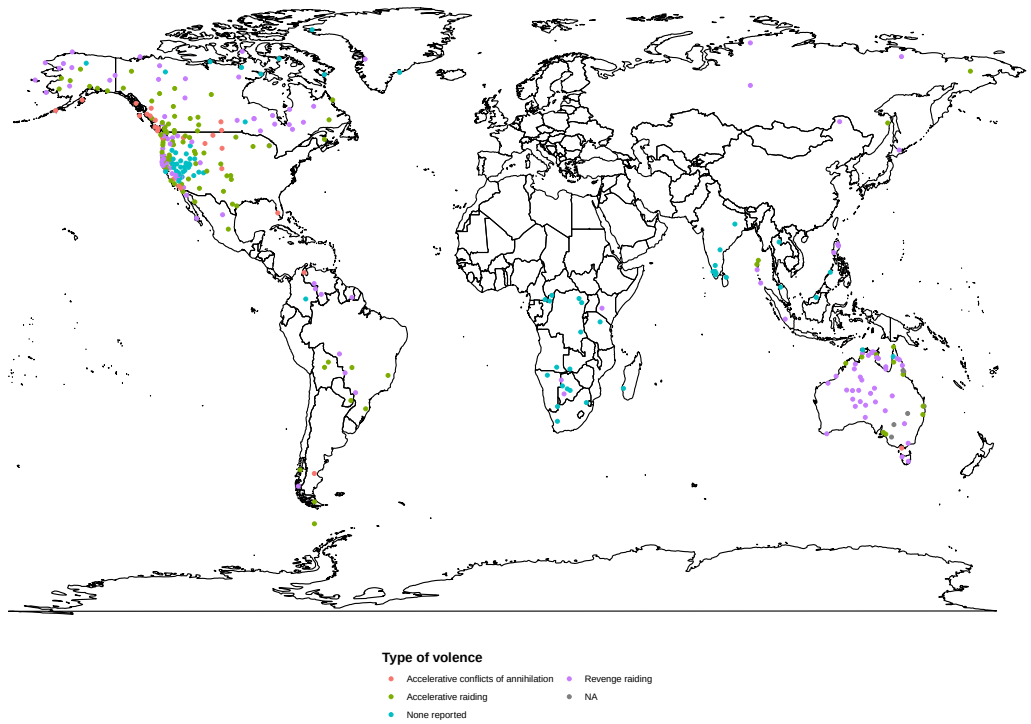


Figure 1.2: Spatial distribution of hunter-gatherer societies, based on the scale of inter-group violence.

Similar patterns of inter-group conflict in hunter-gatherer societies have been observed in other meta-analytical studies. For example, Bowles (2009) has estimated, based on 20 extinct and extant sites, that 14% of the violent deaths can be attributed to violent inter-group conflict. A different study has used data from 50 hunter gatherer groups from the Ethnographic Atlas and has demonstrated that out of all studied societies only three exhibited no warfare (!Kung, Yahgan, and Pekangekum), while most societies exhibited warfare more than once every two years (Ember, 1978). In terms of extinct hunter-gatherer research, archaeological data is more limited the further in prehistory we look. For example, cues of lethal attacks in the archaeological record have been limited to findings about bone fractures, which are not always the leading cause of death during inter-group confrontations (Milner, 2005). As a function of these facts, there is a debate whether warfare has been a prominent part of the life of prehistoric hunter-gatherer groups (Milner,

2005; M. W. Allen, Bettinger, Codding, Jones, & Schwitalla, 2016; Lahr et al., 2016). Therefore, more research is needed to give us a direct insight into the conflict behaviour of extinct human groups.

From a comparative perspective, some forms of inter-group conflict have been observed in multiple species (Rusch & Gavrilets, 2017). Interestingly, a similar pattern of inter-group conflict as the one observed in extant hunter-gatherer societies (low-risk lethal aggression) has been observed in the two philogenetically close species to humans: the chimpanzees and the gorillas (Mikkelsen et al., 2005; Gat, 2008; Scally et al., 2012; M. L. Wilson et al., 2014). This and other findings have led researchers to suggest that lethal violence can be considered a feature of the primate clade (Gómez, Verdú, González-Megías, & Méndez, 2016). Wild chimpanzees, one of the closest living relative of humans (Mikkelsen et al., 2005), may exhibit direct between-group interactions with neighboring groups, which occur during patrols, and may escalate to complete annihilation of one of the competing groups (Goodall, 2010; Feldblum, Manfredi, Gilby, & Pusey, 2014). Bigger groups of predominantly male individuals tend to attack individual members of opposing group, when having superiority in numbers (Wrangham & Glowacki, 2012; M. L. Wilson et al., 2014; Glowacki, Wilson, & Wrangham, 2017). Lethal between-group encounters have been observed in mountain gorillas as well (Rosenbaum, Vecellio, & Stoinski, 2016). In the Karisoke Research Center in Rwanda, 25% of the gorilla groups have a multi-male, multi-female social structure, while 75% of the groups have the classical one male to multiple females harem structure. On this site, out-group attacks have been observed on multiple occasions, and their structure resembles the one observed in wild chimpanzees (e.g. multiple members attacking a single individual) (Rosenbaum et al., 2016).

To sum up, the "us vs. them" collective action problems are potentially a recurrent part of the evolution of the Homo lineage, as shown from both ethnographic and comparative perspectives. Extant hunter-gatherer groups and some non-human

primates have a propensity for low-risk lethal aggression toward out-group members. This suggests that they may be qualitatively different from the "us vs. nature" collective action problems, and thus worth to be studied separately.

1.1.2 Group structure

Hierarchical and egalitarian groups

Groups may have multiple structural variables which underline their performance in collective action problems. For example, previous research has shown that group size (Ingham, Levinger, Graves, & Peckham, 1974; Mao, Mason, Suri, & Watts, 2016) or gender composition (Fenwick & Neal, 2001; Apesteguia, Azmat, & Iriberri, 2012) may influence the cumulative effort of the group. In this thesis I concentrate on hierarchy as one potential influential variable. Hierarchy can be seen as the implicit or explicit rank order of individuals or groups with respect to a valued social dimension (Magee & Galinsky, 2008). Hierarchies are present across all forms of organizations (Magee & Galinsky, 2008). Even if suppressed, they emerge again (Leavitt, 2005).

Relative rank in any hierarchy is based on the relative possession of these valued social dimensions. Thus, we speak about economic and political hierarchy. We can also speak about other forms of hierarchy — dominance-based, prestige-based, etc. For instance, in dominance hierarchies, such as the ones observed in primates (Boehm, 1999), the relative possession of force is important, while in human hierarchies, the relative possession of prestige may be of a higher value (Henrich et al., 2001). For agriculturalists and industrialized societies, the relative possession of institutional power (political position) or resources (money, goods) can bear more weight (Borgerhoff-Mulder et al., 2009; E. A. Smith et al., 2010). Both in extant and extinct human societies, as well as in non-human primates, a higher rank in a hierarchy can be "exchanged" for evolutionary advantages in

terms of survival and reproduction (Price & Van Vugt, 2014). An egalitarian social system, on the other hand, can be seen as a system type without hierarchy — e.g. a system type where the rank differential between individuals, based on any valued social dimension, is non-existent or minimal. I acknowledge that, at least in the real world, there are limited cases in which groups function without hierarchy, but this definition is a good baseline or control case for comparisons.

Hierarchy and human evolution

In modern societies we observe vast political hierarchies. Modern humans live in governments, which are based on differential distribution of power, stemming from top to bottom. Businesses, institutions which feed our economic system and engage the vast majority of humans, are often hierarchical — with well defined roles of leaders (managers) and followers (workers). Military institutions are based on chains of command, where a high-rank officer can transmit decisions to first-line solders without direct contact. These observations may at first make us believe that humans have a set of fixed preferences which allow them to be submissive in hierarchical political structures.

However, research from hunter-gatherer societies and chimpanzee groups suggests that humans experience flexible preferences toward hierarchy. We can at the same time accommodate hierarchy into our daily life and exhibit behaviour which may be "designed" to resist it.

Decision-making in most hunter-gatherer societies is distributed and based on consensus (Boehm, 1999). In such societies, there is usually a reciprocal economic system of redistribution in place (Layton, 1986; Woodburn, 1982; Flanagan, 1989; Borgerhoff-Mulder et al., 2009; E. A. Smith et al., 2010), as well as a relatively high degree of gender equality (R. B. Lee, 1978; Dyble et al., 2015). In certain cases, hunter-gatherers are supportive of situational hierarchy in the form of leadership, especially when the circumstances require it (Woodburn, 1982; Flanagan, 1989;

Boehm, 1999; C. von Rueden, Gurven, Kaplan, & Stieglitz, 2014; Glowacki & von Rueden, 2015). Within the Hadzha (Woodburn, 1979) and the !Kung (Marshall, 1960), informal leaders organize camp, without imposing their will on others. Furthermore, leaders coordinate hunting activities and supervise division of the spoils (see Balikci (1970) and Weyer (1969) for examples with Inuit Eskimos and Lowie (1948) for examples with American Indians).

If such situational leaders or any individual tries to impose his power or monopolize valuable resources, hunter-gather groups are likely to fight him by forming coalitions of conspecifics (Boehm, 1999). There are multiple *leveling mechanisms* through which low-rank conspecifics are able to control potentially dominant and coercive high-rankers, which range from negative opinions, criticism, or ridicule to deposition, desertion, exile, and even execution. According to Boehm (1999), hunter-gatherers would want strong, brave, generous, strategical, and moral leaders, but they still have ethos which "works" against aggressiveness, prominence and other negative characteristics. Subordinates would fight dominance, but at the same time would tolerate it to a certain degree. For instance, the Arapho "expect their chiefs to be strong with whites and humble at home" (Boehm, 1999, p. 84).

Interestingly, in human societies, there is a correlation between the degree of hierarchy and war. For instance, in the Standard Cross-Cultural Sample (Murdock & White, 1969), 74% of foragers exhibit informal leadership during war (Hooper, Kaplan, & Boone, 2010), while in a sample dataset of 339 hunter-gatherer cultures, collected by Binford (2001), out of the 331 societies with sufficient data, 317 had informal leadership during war, while only 14 did not have such a role. Therefore, a good case may be made that informal leadership "evolves" in the context of war.

Comparative research also indicates that hierarchy may be a feature of the evolution of the Homo lineage (De Waal & Waal, 2007) and that chimpanzees may exhibit flexible behavioural repertoire toward it, similarly to humans. Chimpanzee groups are differentiated into dominance hierarchies, which are more predominant

and visible among males than among females (R. Wright, 1994; De Waal & Waal, 2007). According to Boehm (2012) and other authors (De Waal & Waal, 2007; Wrangham, 1999), similar but weaker tendencies for anti-dominance coalitions, as the ones observed in human societies, which can undermine a dominant alpha individual, have been observed in chimpanzees (usually among male subordinates) and bonobos (among male and female subordinates). Male chimpanzees are ready to form a coalition and challenge high-rank individuals through a direct confrontation or displays. At the same time, low-rank chimpanzees are ready to accommodate submissive behaviour, for example by grooming the alpha individuals or by signalling obedience during greeting (De Waal & Waal, 2007). Interestingly, chimpanzee societies exhibit a higher degree of hierarchy than humans, which, according to Boehm (1999), stems from the fact that it is harder for a human high-ranker to coerce other individuals, due to cultural inventions such as weapons, which make relative size and strength of any single group member unimportant. The development of weapons, together with humans' increased capacity for political cognition and alliance formation, minimizes the probability of becoming an alpha individual for any single member of the human group.

In summary, based on the conceptual framework developed by Sergey Gavrilets and collaborators (Gavrilets & Fortunato, 2014; Gavrilets, 2015, 2014; Perry et al., 2018), collective action problems can be roughly divided into two types — "us vs. them" problems and "us vs. nature" problems. The first type involves competition against other groups either directly or for resources, while the second type involves only strategic action to overcome environmental challenges. Further to that, the framework puts an emphasis on the degree of hierarchy in the group as an important structural variable. As seen, both ethnographic and comparative research supports the idea that the "us vs. them" problems and hierarchy may have been an important part of human evolution and may have shaped our cognitive system.

1.2 Empirical framework

The overarching methodological framework of this thesis is game theory. Game theory is the interactive study of decision-making (Camerer, 2003), both from a theoretical and from an empirical perspective.

The aim of this section is to introduce concepts and empirical frameworks from game theory which will be necessary for the understanding of all subsequent material in the thesis. I will outline the field of evolutionary game theory and how it differs from other analytical approaches inspired by rational choice theory (Section 1.2.1). Furthermore, I will review the field of behavioural game theory (Section 1.2.2) and its shortcomings for the study of evolutionary phenomena, especially when hierarchy is involved as an independent variable. I will introduce two behavioural games, which simulate collective action problems — the public goods games and the contest game.

1.2.1 Evolutionary game theory

Game theory can be divided into two branches: analytical and behavioural (Camerer, 2003). The analytical approach uses mathematical tools to derive the optimal set of strategies in a specific situation, given that all agents involved are rational utility maximizers. It can be divided into two sub-branches: rational choice approach and evolutionary approach.

The goal of the rational choice approach is to calculate the so called Nash equilibrium, which can be seen as the strategy which maximizes the agent's benefit, given the strategies that maximize the benefit of all other participants in the game (Nash et al., 1950). Agents in this framework are assumed to be perfectly rational and fully informed about the context.

The goal of the evolutionary approach is to find the evolutionary stable strategy, which maximizes the fitness of the individual in evolutionary time, given the natural selection forces applied to his/her context (J. M. Smith & Price, 1973).

The rational choice approach thus takes into consideration the absolute gain in terms of benefit of the individual, while the evolutionary approach takes its relative gain, conditional on other strategies in the environment and on evolutionary processes, such as group selection, genetic relation, spatial proximity, and migration (Crowley & Baik, 2010). The differences between these two techniques often lead to different predictions.

1.2.2 Behavioural game theory

The behavioural approach to game theory uses economic games to explore empirically the actual, not the optimal, behaviour of agents (Camerer, 2003). In such games, individuals make choices concerning the redistribution of economic resources, such as money.

In this subsection I will introduce two economic games which simulate collective action problems – the public goods game (Section 1.2.2) and the contest game (Section 1.2.2). I will discuss the contest game in more detail as it is the main empirical framework used in this thesis and can be seen as a modification of the public goods game. Finally, I will discuss some of the shortcomings of these games for the study of evolutionary phenomena in general and hierarchy in particular (Section 1.2.2).

Public goods games

One experimental paradigm from behavioural game theory is the public goods game (Isaac, Walker, & Thomas, 1984). In a round of the game, players in a group each receive an initial monetary endowment; they are then asked to contribute a portion of the endowment (ranging from zero to the full amount) to a public pool of resources. After the end of the round, the sum in the public pool is multiplied and redistributed equally among the participants. This game simulates a vast array of collective

action problems where individuals have to sacrifice their personal gains for the good of the group, as making contributions to the pool may be costly (Camerer, 2003).

The rational decision in the public goods game is to contribute nothing to the common pool because if a player contributes something and all other players contribute nothing s/he will receive less than his/her initial contribution. If s/he contributes nothing, s/he has a chance to earn "free" resources. In experimental settings, the theoretical predictions of no contribution contrast sharply with the empirical findings. Usually, the level of contribution in such games is around 40–60% of the endowment (L. R. Anderson, Mellor, & Milyo, 2008), with declining contribution over time and increase when face-to-face communication is introduced by the researchers (Ledyard, 1994). Thus, at least part of the variance in public good games cannot be attributed to rational consideration alone, which makes the paradigm suitable to study the psychological factors which affect our decisions.

Contest game

An extension of the public goods game is the contest game. Contests can be defined as situations in which "agents exert costly effort, such as money, time, or troops, while competing over the distribution of a scarce resource" (Dechenaux, Kovenock, & Sheremeta, 2015). Thus, contrary to the public goods situations, contests explicitly incorporate "us vs. them" collective action problems in the structure of the strategic interaction. All experimental frameworks assume that the contribution of the individual (e.g. the resources s/he spends) leads to increase in the probability for the individual to win a specific prize (Dechenaux et al., 2015). Thus, contrary to public goods games, in some cases the optimal behaviour is to contribute (Dechenaux et al., 2015).

In a simple group-level version of the contest game, known as the Tullock contest (Buchanan, Tollison, & Tullock, 1980), participants invest in a public pool to increase the probability to earn a fixed prize. For example, in a simple two-group

scenario, which will be used as the main scenario in this thesis, the probability for one group of winning the prize depends on its overall effort and the effort of the other group. The group with more effort, e.g. higher overall contribution or higher value in the public pool, has a higher chance to win (Sheremeta, 2010a).

Stated formally, this means that the probability of winning the prize of each of the two groups (the so called contest success function) can be expressed as follows:

$$P_i = \frac{X_i}{X_i + X_j} \tag{1.1}$$

where P_i is the probability of the focal group to win the prize, X_i is the total effort of the focal group, and X_j is the total contribution of the opponent of the focal group.

The total effort of the focal group (X_i) can be calculated as follows:

$$X_i = \sum_{i=1}^{N} x_i \tag{1.2}$$

where x_i is the contribution of player i of the focal group and N is the number of players in the focal group.

In the theoretical literature this contest success function is known as the perfect substitutes function (Katz, Nitzan, & Rosenberg, 1990). This function is seen to resemble many real life competitions where the success of the group is determined by the sum of the efforts of all its members. It has been used in previous theoretical modeling (Gavrilets & Fortunato, 2014; Gavrilets, 2014, 2015) and in various experimental papers (Nalbantian & Schotter, 1997; Abbink, Brandts, Herrmann, Orzen, et al., 2010; Ke, 2011; Sheremeta, 2011). A visual representation of a hypothetical contest game between two groups of four players can be seen in Figure 1.3.

This definition of the contest game with a perfect substitutes Tullock function can be seen as analogical to the "us vs. them" type of collective action problems.

Group's success rate in this case is dependent not only on its own contribution but also on the contribution exerted by the other group.

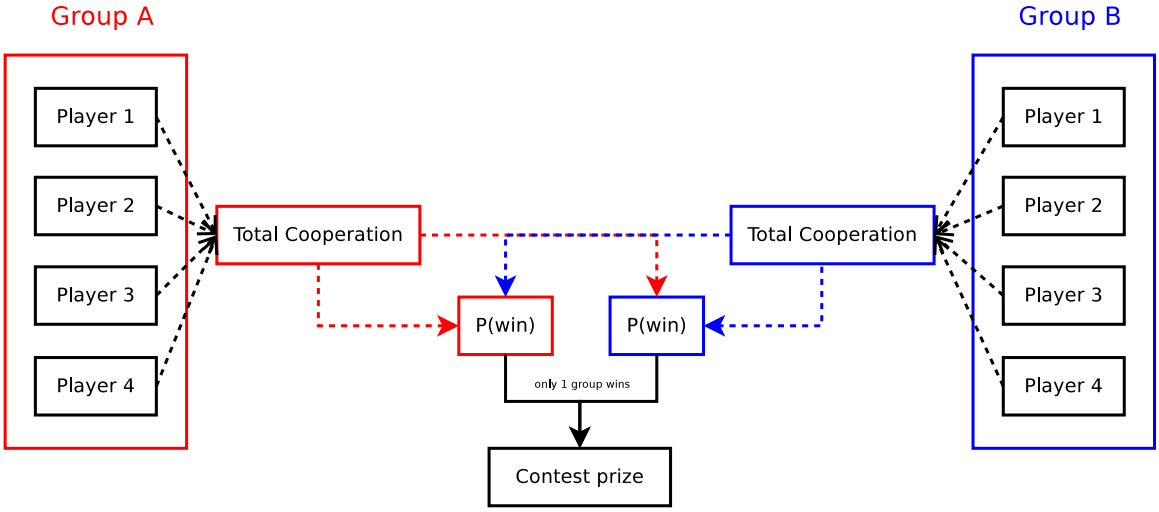


Figure 1.3: A visual representation of a contest game between two groups of four players each. Group A is represented in red, while Group B is represented in blue. Each group produces a total effort, which is the sum of the contribution decisions of all its members. The probability of each group to win the contest prize, P(win), is a function of its total effort and the total effort of the other group. Only one group can win the contest prize.

In a similar vein with the public goods game, participants in contest games exert more effort toward the solution of the problem at hand than expected by rational choice theory (Abbink et al., 2010; Sheremeta, 2010b; Sheremeta & Zhang, 2010; Ke, 2011; Dechenaux et al., 2015). Thus, they are willing to sacrifice their personal benefit for the good of the group.

Shortcomings of economic games

It is important to note that economic games have several notable shortcomings. First, most economic games, especially when executed in laboratories, represent participants with an abstract situation, which makes them less likely to act as if in naturalistic settings, as few real-world interactions are ever one-shot and anonymous (Levitt & List, 2007; Baldassarri & Abascal, 2017). Therefore, an argument can be made that results from laboratory experiments are not generalizable to the real world. However, previous experimental studies have demonstrated that behaviours

observed in the lab, when tested in corresponding field settings, do generalize. For instance, Benz and Meier (2008) showed that when participants were asked to donate to a charitable cause both in the lab, by being given a fixed amount of resources, or in the field, by being asked to donate part of their money, they were donating on average a similar amount. In a related study, which simulates a Dictator's game, Winking and Mizer (2013) demonstrated that when participants' "giving" preferences were tested in the lab, and when they were compared with the participants' willingness to turn-down a misdirected mail delivery, containing money, the correlation between the two settings was high, suggesting genralizability of the results. Indeed, in a literature review on this topic, Camerer (2011) explored six experimental studies, employing game theory frameworks, which have close match between experimental and field settings. He showed that in five of the experiments the results between lab and field closely resembled each other, while only in one of the experimental studies there was a mismatch. Experiments in the public goods game paradigm have also demonstrated generalizability. For example, as climate change can be seen as a collective action problem, in one experimental study Goeschl, Kettner, Lohse, and Schwieren (2015) have demonstrated that participants who contribute a lot in the public goods game, contribute also significantly in a real-giving task, where participants make donations, used to reduce C02 emissions. When the structural similarity between the two tasks was high, the correlation between the two proxy measurements of individual effort was also high.

Still, the research in this area is quite limited, therefore further studies are needed to explore the link between lab and real-world behavioural patterns. Despite all that, experimental studies are not always contradicting lab experiments, even if the results are not similar. Indeed, when experimental research is done, researchers trade ecological validity for higher experimental control. This means that real-world experiments also have shortcomings, namely the fact that the specific context of the experiment may have multiple interacting external factors, which may reduce the

interpretibility of the findings or may lead to inferences only possible in the specific context. In other words, laboratory and field studies compliment each other, by providing information about the problem from two different perspectives.

Second, it is hard to disentangle whether participants' preferences (for instance the average levels of effort) are driven by their evolved psychological predispositions, by rational considerations, by their cultural background, and/or by their learned strategies over a lifetime. Thus, researchers cannot make direct conclusions about evolutionary fitness without taking into account a cross-cultural, comparative, and/or developmental perspective (Laland, Sterelny, Odling-Smee, Hoppitt, & Uller, 2011). To mitigate this issue, one needs to run experiments with diverse samples, and with various operational definitions of the variables of interest, in order to approximate a universal behaviour, if any. In this thesis, I aimed to do the experiments in three different national groups, with various operational definitions of the variables under study, however much more effort is needed in future research.

Finally, in such behavioral game theory games it is hard to make sure that participants understand the precise rules of the game and the context they are placed in, thus it may be the case that their decisions reflect poor understanding rather than cooperative behaviour (Andreoni, 1995; Burton-Chellew, El Mouden, & West, 2016). To mitigate the issue, in the experiments of this thesis I have included various comprehension tests and exclusion criteria for participants with poor understanding of the setup.

An additional problem of economic games for the study of evolutionary phenomena stems from the fact that there are multiple possible operational definitions of hierarchy. In this thesis, I concentrate on two definitions — economic and political hierarchy.

In economic hierarchies, individuals are differentiated based on economic resources. Usually, most experiments in behavioural game theory are executed with this specific form of hierarchy. In my operational definition of economic hierarchy,

which is used in the first two studies in this thesis, I differentiate participants based on their income — e.g. based on how much they are to earn from the prize in a contest game. The drawbacks of the study of such hierarchies, based on differences in income or wealth, is that it is not clear whether a behavioural change can be attributed to the psychological predispositions of players for contribution or to rational considerations. For instance, if in an economic game players are divided based on their income, and if we find that higher-rank players (e.g. who earn more) are more likely to contribute than lower-rank players (e.g. who earn less), it is unclear whether the effect can be attributed to the fact that (i) high-rank players have a preference to contribute more than low-rank players, (ii) that they contribute more because they will earn more when their group wins, or (iii) both. In other words, this form of hierarchy, and most games with economic incentives, have an inherent confound between psychological predispositions and rational considerations.

This criticism of the study of effort in economic games is applicable to all experiments in the first empirical chapter, where I operationalize hierarchy in terms of economic income. To mitigate the issue, in the second empirical chapter I tested the same hypotheses with a different form of hierarchy, political hierarchy, where the differences between different player ranks are not based on income or wealth, but are based on influence. More specifically, in groups with political hierarchies, some individual were allowed to influence the decisions of all members of the group, while other individuals were not able to do so. Thus, a difference in the contribution preferences of players of different ranks is more likely attributable to their psychological predispositions than to rational considerations.

1.3 Models of hierarchy and collective action

Imagine an "us vs. them" collective action problem, such as a war. During war, troops need to act fast and groups of troops need to have contextual information (e.g. where the enemy is). Furthermore, action requires steps which are synchronous and sophisticated (such as raiding a building or defending a fort). Critically, there is a high cost of failure, as the failing group will likely exhibit high death rates. Indeed, as seen both in hunter-gatherer and non-human primate groups, failure in inter-group conflict and competition can result in group annihilation (Binford, 2001; Goodall, 2010). In such situations, groups may be unable to solve the collective action problems by utilizing mechanisms, such as true altruism, reciprocity, reputation, internalized social norms, and third-party punishment (McElreath & Boyd, 2007; Nowak, 2006; Richerson & Boyd, 2005; Bowles & Gintis, 2011). In this section, I will discuss theoretical results which suggest that hierarchy can solve the paradox (Gavrilets & Fortunato, 2014; Gavrilets, 2015; Zhuang et al., 2012).

More precisely, in Section 1.3.1 I will review recent theoretical work on the effects hierarchy on collective action with an emphasis on "us vs. them" collective action problems. I will concentrate evolutionary accounts from Sergey Gavrilets and colleagues (Gavrilets & Fortunato, 2014; Gavrilets, 2015; Zhuang et al., 2012). Moreover, I will discuss how these results can be understood from an evolutionary cost-benefit perspective (Section 1.3.2). The literature suggests that under "us vs. them" collective action problems, high-rank individuals in hierarchical groups are expected to contribute more to the group's success and subsequently, in some cases, to earn less from the reward. This over-contribution is expected to lead to increased performance of hierarchical groups in comparison to egalitarian groups, thus increasing the beneficial effects of this group structure on the fitness of the individual. However, hierarchy may have some costs as well, which mainly concern low-rank individuals in the group — lower reproductive success, health, and access

to basic resources, among others.

1.3.1 Review of theoretical work

Gavrilets and Fortunato (2014) used the contest game paradigm to study the evolutionary dynamic which underpins the behaviour of agents, through multi-level mutation-based evolution with group-level selection. Their results suggest that the total effort of groups (e.g. the total effort of all individuals) increases as the number of ranks within the group who actively contribute effort decreases. Thus, increase in inequality (or hierarchy) increases group effort, and the fitness of the low-rank agents. The rationale is that high-rank individuals in hierarchical groups become the sole contributors and effectively compete against high-rank individuals in other groups. Low-rank individuals, on the other hand, tend to free-ride. The effort of the high-rank group members increases as a function of the level of hierarchy in the group, with higher inequality leading to higher contributions (Gavrilets & Fortunato, 2014). The increased contributions of the high-rank individuals increase the group effort and make hierarchical groups solve the "us vs. them" collective action problems better than egalitarian groups. Interestingly, as a function of their high effort, high-rank group members are expected to benefit less from the strategic situation during "us vs. them" problems, a phenomenon coined the altruistic bully hypothesis (Gavrilets & Fortunato, 2014), which will be further tested extensively in this doctoral thesis.

These results have been replicated by other theoretical papers by Gavrilets and collaborators. For example, Gavrilets (2014) introduced "us vs. nature" problems to the modeling framework. He found that when groups solve this collective action problem type, individuals are expected to exert non-zero effort under limited circumstances, while "us vs. them" problems are expected to lead to a positive effort in most cases. Finally, Perry et al. (2018) replicated these results to models with punishment and foresight. Furthermore, they showed that in these cases

high-rank individuals in hierarchical groups will specialize in costly punishment, thus contributing to the collective action problem solution through an alternative channel, which still requires exertion of individual effort.

Some of the findings from Gavrilets and collaborators have been supported by other theoretical models, both studying the evolutionary stable state of this strategy (Crowley & Baik, 2010) and its rational choice implications (Olson, 1965; Crowley & Baik, 2010). Indeed, their theoretical results are similar to the observations made by Olson in his classic work "The Logic of Collective Action" (Olson, 1965), a magnum opus in the field of rational choice theory. His findings are that "us vs. nature" collective action problems are solved solely by the high-rank members. In such cases, low-rank individuals are expected to free-ride and "abuse" the effort invested by high-rank group members, a phenomenon coined the "exploitation of the great by the small". Further to that, he found that group size decreases effort while punishment and reward, as institutional rules, can promote it. However, in comparison to Gavrilets and Fortunato (2014), the results from Olson's research were weaker and disregarded the "us vs. them" cases. The main prediction from the modeling work presented by Gavrilets and Fortunato (2014), which differs from the classical results by Olson, is that the effect will be further exacerbated during "us vs. them" collective action problems, to a degree that high-rank individuals will be worse off than low-rank individuals in terms of net benefits from the game.

In a different line of research, Makowsky and Smaldino (2016) utilized agent-based simulations, inspired by cultural group selection theory, to discover that as the amount of "us vs. them" collective action increases, groups with unequal power thrive. They operationally classify groups on a continuum from democratic (where all individuals can influence the decisions of all other individuals to an equal degree) to autocratic (where one individual can influence the decisions of all other individuals). The authors manipulated the degree of conflict, defined as the rate of strategic interactions between groups. On the group level, groups were matched with

other groups to play a strategic game (known as the Hawk game). All group members made a collective decision about the group effort in the game. Furthermore, the researchers introduced a degree of power inequality in the group, where members with more wealth were able to influence the group decision to a higher degree. In terms of hierarchy, the model showed that with higher rates of "us vs. them" problems autocratic groups were able to control more resources than democratic groups. Moreover, members of more autocratic groups had reproductive advantage over members of more democratic groups under the interaction of population mixing and high degrees of "us vs. them" collective action problems.

Other research efforts in this area have tackled the effects of collective action problems on hierarchy as well. For example, Zhuang et al. (2012) found that in groups where high-rank individuals are able to reward others, effort is promoted (in comparison to groups where they can lead by example or punish). In a set of papers, Santos, Pacheco, and Lenaerts (2006) and Santos, Santos, and Pacheco (2008) used a social network definition of hierarchy, where individuals were different in terms of their connectivity in the group (higher-rank players were more connected). They found that in this case network hierarchy also promotes effort significantly. In a different line of research, Fu, Liu, and Wang (2007) found that this effect is not sustained under the highest possible or the lowest possible social network hierarchy. Only intermediate levels of hierarchy produced increases in effort levels.

Finally, other research papers have also shown that high-rank individuals exert more effort than low-rank individuals. For instance, when rank was defined in terms of endowment, Frank (2010) found that effort increases, while McGinty and Milam (2013) found that valuation increases individual effort. He, Wang, and Li (2014) found that only one possible evolutionary stable strategy leads to higher effort by individuals with higher valuation. In "us vs. them" problems, when the contest game paradigm is used to frame simulations, higher valuation individuals are observed to produce more effort as well (Epstein & Mealem, 2009).

Generally, the body of work presented in this review suggests that hierarchical groups are expected to outperform egalitarian groups, especially during "us vs. them" collective action problems, due to higher effort by the high-rank individuals. A novel proposal, known as the altruistic bully effect, suggests that this increase in effort may decrease the benefit of high-rank players in comparison to low-rank players, especially during "us vs. them" problems. All in all, despite convergence in results, the theoretical literature on collective action problems and hierarchy has several limitations, including relatively small body of work and the wide diversity of operational definitions of hierarchy (for instance based on power, valuation, connectedness, or resources). Therefore, empirical research may be needed to shed further light on this problem.

1.3.2 Benefits and costs of hierarchy

Benefits of hierarchy

According to the aforementioned models, hierarchy may provide some benefits for group members. If a group with hierarchical social system is more likely to outperform a group with egalitarian social system, this may lead to effects on individual fitness. Indeed, based on multi-level selection theory, the performance of the group reflects on the fitness of its members.

Some additional mechanisms, which may make hierarchical groups outperform egalitarian groups, and which will not be discussed in further detail in this review, include *motivating individuals to exert effort* (Hill & Buss, 2006; Price & Van Vugt, 2014), *resolving internal conflict* (Boehm, 2012, 1999; De Waal, 1990), *reducing the costs of punishment* (Hooper et al., 2010; Baldassarri & Grossman, 2011; O'Gorman, Henrich, & Van Vugt, 2009), and *increasing coordination* (Couzin & Krause, 2003; King, Johnson, & Van Vugt, 2009; Van Vugt, 2006; Van Vugt, Hogan, & Kaiser, 2008), among others.

Costs of hierarchy

Hierarchy, on the other hand, imposes sufficient costs for individuals of lower rank. Overall, being of a lower position in any form of hierarchy, being dominance-based, resource-based, prestige-based, or political (institutional), makes one's preference less important. This can lead both to individual and group-related costs. However, even if there is no collective action problem to be solved at the moment, a lower relative position in a hierarchy could lead to negative consequences, such as *reduced reproductive success*, *reduced access to basic resources*, and *reduced health*.

Indeed, one consistent finding within evolutionary biology is that low-rank individuals exhibit lower levels of reproductive success, defined as the number of offspring left by an organism in all subsequent generations, in comparison to high-rank individuals (usually the individuals with higher degree of dominance) (Johnstone, 2000). Within both male and female primate and non-primate species, dominance is positively correlated with reproductive success (Ellis, 1995). Within human groups, similarly higher rank in any form of hierarchy (for example physical, prestige-based, wealth-based, or political) is correlated with higher reproductive success (Betzig, 1993; C. R. von Rueden & Jaeggi, 2016). Furthermore, wealth and income redistribution within industrial societies, which go well beyond the basic resources needed for survival, is also skewed toward high-rank individuals (Borgerhoff-Mulder et al., 2009). Resource inequality is also transferable over generations where the offspring of a low-rank individual is more likely to be of low rank himself, which is especially important in humans that are not hunter-gatherers (Borgerhoff-Mulder et al., 2009; E. A. Smith et al., 2010).

Finally, the health status of low-rank individuals in different forms of hierarchy can be seen as another cost of hierarchy. Low-rank individuals within non-human primate dominance hierarchies may have higher levels of stress, especially if the social order is characterized by significant resource inequality, stability of rank, and

reproductive skew (Sapolsky, 2005). Animals who exhibit higher levels of stress, mediated through stress hormones, such as cortisol, adrenaline, and corticosterone, have subsequently diminished reproductive rates (Moore & Zoeller, 1985). Moreover, stress can influence the cognitive system both in humans and non-human species (Sandi, 2004), by introducing a wide variety of cognitive biases (Haushofer, 2011) and mental health problems (Schneiderman, Ironson, & Siegel, 2005).

In summary, while the benefits of hierarchy are clear, as it can use multiple mechanisms to increase group effort, its costs, such as reduced reproductive success, reduced access to basic resources, and reduced health, are significant as well.

1.4 Empirical results from behavioural game theory

Based on the presented research in Section 1.3, we can derive three main research questions regarding the individual effort and benefit of players of different ranks within hierarchical groups and the group effort of hierarchical and egalitarian groups. In Section 1.4.1 I will explore what is the effect of rank on individual effort. I will concentrate my review on two types of rank — one based on economic inequality and one based on political position. Similarly, in Section 1.4.2 I will explore the effects of rank on individual benefit, especially during "us vs. them" collective action problems, to see whether the altruistic bully hypothesis has been previously explored. In Section 1.4.3 I will explore what is the effect of system type (hierarchical vs. egalitarian) on group effort, during "us vs. them" problems. Further to these research questions, I will study three additional questions throughout the empirical portion of this thesis. In Section 1.4.4 I will study the effects of the type of collective action problem ("us vs. them" or "us vs. nature") on individual effort. Based on previous research in evolutionary biology and psychology, the prediction regarding this question is that humans are expected to exert more effort during "us vs. them" than during "us vs. nature" problems. In Section 1.4.5, I will review previous literature which points that gender may be also an influential variable for the effort of players, as male participants are expected to exert more effort toward the group's success than female participants, especially during "us vs. them" collective action problems. Finally, in Section 1.4.6 I will review how the decision making speed affects the contribution decisions of participants. Previous research suggests that when participants are making decisions faster, usually under a pre-defined time pressure, they are likely to exert more effort than when they are making their decisions slower.

To test the first three research questions, a more elaborate definition of the effect

of interest in this thesis is required. As the superior effort of hierarchical groups is expected to be a function of the effort of the high-rank individuals, I have used the difference in the contribution levels between the high- and the low-rank players as an effect of interest (which always had the same endowments). Alternative ways to operationalize the effect of interest for these hypotheses may be based on overcontribution, for instance contributing more than a rational threshold (like a Nash equilibrium). However, there are two issue with this approach. First, there are multiple ways to define a rational threshold, most of them based on an equilibrium analysis. Depending on the approach selected, the threshold may differ. For instance, equilibrium analyses based on evolutionary game theory often produce different results, in comparison to equilibrium analyses based on rational choice theory, especially in contest games (Hehenkamp, Leininger, & Possajennikov, 2001; Leininger, 2003).

Therefore, to remain agnostic toward a specific theoretical tradition in rational threshold estimation, and all possible corresponding sub-variants, I decided to look at a more standardized approach, namely based on the effect size of the difference between the player ranks. When appropriate, the contributions of the low- and the high-rank players have been compared to contributions of players in egalitarian groups, to further confirm whether the difference between the hierarchical and the egalitarian groups, if any, is driven by the higher contribution of the high-rank players. Therefore, I will not use terms like free-riding and over-contribution in the empirical portions of the thesis.

In the remaining subsections, I will review literature from the field of behavioural game theory which studies these hypotheses. I will concentrate my effort on such experiments, as behavioural game theory is the main paradigm used throughout this thesis.

1.4.1 Rank and individual effort

Rank within hierarchical groups has been studied as an explanatory variable for individual effort with both public goods games and contest games. In both games, results suggest that high-rank players usually exert more effort than their low-rank groupmates.

In public goods games with *economic hierarchy*, rank is usually defined as income or wealth heterogeneity, where individuals with higher rank either receive a bigger portion of the public good after multiplication or have a higher initial endowment. For example, Fisher, Isaac, Schatzberg, and Walker (1995) showed that when participants were set to receive a better multiplication factor (e.g. a better share of the public good), they were contributing a bigger percentage of their endowment toward the group's success in comparison to participants who received a smaller multiplication factor. Other studies further suggested higher effort by economically high-rank individuals in public good games (Reuben & Riedl, 2009). In a different set of games, Chan, Mestelman, Moir, and Muller (1996), high-rank players contributed more than low-rank players, with amounts proportional to the income they have received. Buckley and Croson (2006) executed a simple public goods game on groups of four participants. In each group, two of the participants received a higher income from the game, while the other two participants received a lower income. All participants made ten subsequent decisions, where the income was defined as the amount of points that are added to their endowments after each round. The results from the study showed that high-rank subjects gave approximately the same absolute amount as the low-rank subjects to the public pool. However, low-rank subjects gave a bigger percentage of their endowment. Thus, in absolute terms, there was no difference, while in relative terms, low-rank individuals contribute more. In sum, one finding from the empirical literature on economic hierarchy is that high-rank individuals tend to contribute more than low-rank individuals. Still,

there are conflicting results, as shown by Buckley and Croson (2006).

In public goods games with *political hierarchy*, rank has been defined to reproduce a typical leadership-followership dynamic. This literature usually recreates conditions where participants with higher rank are more likely to act first (e.g. to lead). In these cases, the most common observation is that high-rank players (or leaders) are more likely to contribute as first movers. Such players increase the effort of other group members by reducing the costs of coordination through their altruistic example. In one experimental study Kumru and Vesterlund (2010) found that when participants were divided into leaders and followers in a sequential public goods game, leaders were more likely to contribute first than followers and to exhibit higher levels of effort when first-movers. Furthermore, if followers followed leaders who exerted more effort, they were more likely to exert more effort themselves. Similar results have been observed in experiments with university students, where participants were assigned to be low- or high-status based on their educational level (low status was assigned to graduate students, while high status was assigned to high school students). If students were assigned a high status, they were more likely to contribute as first movers (Simpson, Willer, & Ridgeway, 2012). When leaders were directly defined as the only players that are allowed to make the first move in a public goods game, the results revealed that the behaviour of such players influenced the decisions of others and subsequently increased their effort (Potters, Sefton, & Vesterlund, 2007; Güth, Levati, Sutter, & Van Der Heijden, 2007). In sum, the aforementioned results show that the introduction of a political hierarchy increases the success rate of the group in collective action problems, as predicted by various theoretical accounts (Van Vugt, 2006; Van Vugt et al., 2008; King et al., 2009). Leaders are better contributors and give solid example, which is usually followed by lower-rank players.

Hierarchy has been studied in contest games as well. Similarly to the literature on public good games, the first finding from the literature on hierarchical contests is that

indeed the relative rank of a players does affect their degree of effort. For instance, Brookins, Lightle, and Ryvkin (2015) assigned participants into four ranks, based on their cost of effort. Participants played contest games in groups of two under varying conditions. The higher the rank of an individual, the higher his/her effort. Again, they observed substantial over-contribution in all cases. In a second experimental study the same research group replicated the same results with a slightly modified setup (Brookins et al., 2015). Sheremeta (2011) showed that high-rank players that earn a higher share of the prize contribute significantly more than low-rank players.

In summary, the literature on rank and effort converges toward the idea that higher-rank players, defined either in economic terms or as the group's leaders, are more likely to exert more effort toward the success of the group, as proxy measured through their contributions, both during "us vs. them" and during "us vs. nature" collective action problems. Indeed, this is congruent with the theoretical literature on hierarchy as a potential solution to the puzzle of cooperation, which suggests that players with higher rank may be driving the performance increase of hierarchical groups in terms of group effort in comparison to egalitarian groups (Gavrilets & Fortunato, 2014; Gavrilets, 2015).

1.4.2 Rank and individual benefit

The contribution preferences of players affect their corresponding benefits, which may differ as a function of their rank. Indeed, based on theoretical models, high-rank individuals may contribute more than low-rank individuals and thus incur higher costs to themselves. This effect is expected to be particularly pronounced during "us vs. them" collective action problems (Gavrilets & Fortunato, 2014; Gavrilets, 2015). Unfortunately, this questions has not been studied often in the behavioural game theory literature, thus I will include in the discussion research stemming from observational studies as well, which suggests that military leaders either in modern

armies or in small-scale societies draw more risk during conflict and thus may actually incur higher costs on themselves in comparison to their low-rank groupmates.

In terms of experimental literature, the only empirical support for the altruistic bully hypothesis comes from punishment experiments. Punishment can be seen as a second-order collective action problem, as individuals incur costs to themselves in terms of time or resources (Dreber, Rand, Fudenberg, & Nowak, 2008). Thus, punishment can be taken as a proxy for individual effort. Previous studies have found that high-rank players are more likely to punish others and thus earn negative net benefits from the strategic encounter (Baldassarri & Grossman, 2011; O'Gorman et al., 2009). For example, Diekmann and Przepiorka (2015) ran a public goods game with punishment, where the cost to punish was experimentally modified. In one treatment, the cost of punishment exceeded the potential benefit, thus the rational choice expectation was that no one will use the punishment option. In the other treatment the cost of punishment was smaller than the potential benefit. Moreover, in one condition the authors created a form of hierarchy, where some individuals in the group had a high punishment cost (low-rank), while other individuals had a lower cost (high-rank). In all cases, when hierarchy was introduced, high-rank players were more likely to punish free-riders to sustain the overall group effort than low-rank players. Thus, in the condition where the cost of punishment was higher than the potential benefit, high-rank players were taking disproportionate costs to sustain punishment in the group in comparison to low-rank players. Such results present a good initial support for the altruistic bully hypothesis, however the study does not explicitly involves an "us vs. them" collective action problem.

When "us vs. them" problems are involved, preliminary social science research has shown that the mortality rates of high-rank warriors may be higher than the mortality rates of low-rank ones. For example, Buzzell and Preston (2007) have shown that between 2003 and 2006, 2706 deaths occurred in the lines of US troops fighting in the Iraq war. They showed that both within the Army and

the Marines, enlisted men had around 35% increase in death rate in comparison to officers. However, in both branches of service, lieutenants, the lowest-ranking officers, who are typically the combat leaders, exhibit higher death rates than the average death rate within the enlisted units. Thus, in this case, leaders exhibit higher mortality rates than the average follower, probably due to the increase in effort (e.g. taking more personal risks for group gain). In a different study, the same effect was observed in the small-scale Nyangatom society (Glowacki & von Rueden, 2015). The Nyangatom are nomadic agro-pastoralist, living in the territories of Ethiopia, South Sudan, and Kenya. They often engage in inter-group conflict with neighbouring ethnic groups, usually through small-scale raids. Thus, they represent a typical case of small-scale raiding behaviour, often observed in hunter gatherers and non-human primates. Occasionally, there are bigger raids, involving hundreds of warriors. Leaders in such cases are situational and they facilitate the initiation of the raid and the recruitment of enough warriors. During fight, leaders do lead in battle and solve various tactical and strategic problems. From long-term ethnographic research the authors studied whether battle leaders exhibit higher fitness in comparison to other warriors. They compared a sample of battle leaders and warriors who were not leaders and found that battle leaders were more likely to take more risk and die during battle (Glowacki & von Rueden, 2015).

This research should be taken with a grain of salt. First, in order for this to be valid, we need to assume that mortality rates are proxies for evolutionary fitness. If that assumption holds, high-rank individuals may be seen as the main contributors (e.g. altruistic bullies) in their respective groups (being the US military or Nyangatom warriors), who are more likely to take risks and die than a low-rank member. Second, we need to assume that the altruistic bully effect applies only to high-rank group members which do solve collective action problems with the rest of the group. Thus, we should include high-rank warriors and lower-ranking officers, but exclude high-grade military commanders, such as kings, generals, etc.

Third, the number of studies and their corresponding sample sizes are rather small, therefore further research is needed in order to make the results more plausible.

In sum, one critical prediction derived from the collective action problem literature is the so called altruistic bully hypothesis. Experimental research regarding this hypothesis is practically non-existent, while some observational studies only suggest a possible effect, but have multiple limitations in terms of sample sizes and assumptions made. Therefore, a direct empirical evaluation of the hypothesis is needed.

1.4.3 System type and group effort

To study the effects of system type on effort, behavioural game theorists have used experimental games and rank manipulations in a similar fashion as presented in the previous subsections. However, results in these cases are rather mixed, as some studies suggest that hierarchical groups outperform egalitarian groups, while other experiments reveal no effects or reversed results. Furthermore, based on my knowledge, most experiments which compare different system types do so with economic instead of political definitions of hierarchy.

Indeed, empirical findings from experimental and field public goods games suggest rather mixed results. For example, under economic hierarchy, which is defined usually as income inequality within the group, Reuben and Riedl (2009) showed that hierarchical groups exerted more group effort than egalitarian groups over the full duration of the study. This was the case only when punishment was not introduced to the experimental design. Chan et al. (1996) showed that in a modified public goods game with groups of three participants a gradual increase in the degree of hierarchy (defined both as endowment- and income-based) increased the effort levels of players. In the most extreme condition, where one player received over 4.6 times more than the other two players, the mean effort was the highest.

Different authors have found the opposite effect. Rapoport and Suleiman (1993) used a threshold-based public goods game, where players are expected to reach a specific group contribution. If the threshold is reached, their group contribution is multiplied and redistributed. The authors defined hierarchy based on the initial endowment of participants (e.g. on wealth). They found a decrease in effort for hierarchical groups, when they compared them with results from egalitarian groups taken from an equivalent study (Suleiman & Rapoport, 1992). Similar decreases in effort as a function of hierarchy have been observed in other experiments as well (Bagnoli & McKee, 1991). However, in a working paper L. R. Anderson, Milyo, and Mellor (2004) showed that if players received an unequal show-up fee for the experiments (and they were made aware of that information), the effort levels dropped. In a subsequent study L. R. Anderson et al. (2008) further showed that when in a public goods game information about income inequality was public (e.g. all participants were aware), effort in egalitarian groups was relatively higher than effort in hierarchical groups. Finally, lack of effect of the degree of hierarchy has been observed as well (Marwell & Ames, 1979; Van Dijk & Grodzka, 1992).

In real-world settings, steep differences in economic income have been found to be predictive of both lower and higher effort. Cardenas (2003) surveyed the household incomes of Colombia villagers. Participants then played a type of public goods game, framed as a tragedy of the commons problem, where each participant was asked how much would s/he like to exploit a local forest. The effort decision is to state a low amount of exploitation, thus maximizing group gain and minimizing personal gain. After post-experimental evaluation they found that the degree of wealth inequality in the group was predictive of the overall increase in effort. Participants who were in more unequal groups were less likely to contribute toward the group's success, especially if they were more affluent than others. Further studies have shown that inequality in earnings is correlated with lower performance among academic departments (Pfeffer & Langton, 1993).

When hierarchical groups are compared with egalitarian groups in contest games, the results are also mixed. In one study Gunnthorsdottir and Rapoport (2006) executed a between-group contest, where groups shared the prize either in an egalitarian or in a hierarchical way. In the egalitarian case, all players received an equal share of the prize. In the hierarchical case, the prize was divided in proportion to the effort of each group member. The higher the effort of a group member, the higher his/her share of the prize. The research suggests that the latter system was capable of producing significantly higher effort. Similar results have been observed by Kugler, Rapoport, and Pazy (2010). In a different experiment, Ke (2011) found that an equal probability of winning the prize within the group produces higher contributions than proportional probability. Finally, in a novel study Doğan, Glowacki, and Rusch (2018) ran a two-group contest game in Ethiopia. Participants of three ethnic societies formed homogeneous groups and played against each other. Some groups were antagonistic to each other (e.g. with past raiding history), while other groups were neutral. The researchers found that the framing of the contest as antagonistic or neutral affected only egalitarian groups, which increased their performance when the opponent was from an enemy group.

In sum, public goods and contest game experiments show rather mixed results, as in some experiments hierarchical groups outperform egalitarian groups, while in other experiments the result is reversed or an effect is not found. It is important to note that most experiments in this review are based on economic hierarchy. To my knowledge, the difference in terms of combined group effort as a function of the degree of hierarchy has not been studied with political hierarchy.

1.4.4 Collective action problems and individual effort

Another question of this thesis aims to compare the effect of the collective action problem type on the effort of participants. As mentioned in Section 1.1.1, people

may have evolved to deal with two types of collective action problems — "us vs. them" problems and "us vs. nature" problems. Both types of problems have been a prominent part of human evolution (Gavrilets, 2015, 2014; González-Forero & Gardner, 2018). Previous theoretical work, such as the theory of parochial altruism (Choi & Bowles, 2007; Bowles, 2009), claims that participants may exert more effort during "us vs. them" problems than during "us vs. nature" problems.

Indeed, in a set of experimental studies, researchers have found that humans have psychological heuristics that allow them to evaluate the context (for instance, are individuals in conflict or not) and to adjust their behaviour accordingly. A whole tradition in social psychology, centred around the concept of out-group salience, was able to show that when participants are divided into groups, randomly or based on previous interactions, they are more likely to exhibit intra-group contribution and inter-group hostility (Tajfel, 1982; Brewer, 1999; Hewstone, Rubin, & Willis, 2002). Participants categorize others into "us" and "them" easily and usually favor the former (Everett, Faber, & Crockett, 2015). Such between-group antagonism is potentially mediated by specific neural correlates (Hart et al., 2000; Van Bavel, Packer, & Cunningham, 2008; Cikara, 2015) and neuro-chemical activations (Everett, Faber, Crockett, & De Dreu, 2015; De Dreu et al., 2010; Diekhof, Wittmer, & Reimers, 2014). Behavioural game theory studies have also demonstrated that the contribution levels of players during an intra-group interaction were significantly higher than during an inter-group interaction (Hewstone et al., 2002; Everett, Faber, & Crockett, 2015). For example, Puurtinen and Mappes (2009) ran an experiment in which participants were assigned to play a public goods game. In some cases, they were matched to play the game in competition with other groups. This manipulation increased their total contribution toward the solution of the collective action problem in comparison to cases without competition. In a different study, when groups in a public goods game were eliminated based on their group performance, in-group contribution increased (Egas, Kats, Van Der Sar, Reuben,

& Sabelis, 2013). If groups competed with each other for a real prize (Burton-Chellew, Ross-Gillespie, & West, 2010) or for no prize whatsoever (Burton-Chellew & West, 2012), the same effect was observed.

Indeed, based on a set of 212 similar studied from the period between 1965 and 2013, which include various behavioural game theory games, such as the public goods game and the prisoner's dilemma game, Balliet, Wu, and De Dreu (2014) revealed that the mean effect size of the difference in contribution when a participant contribute with an in-group in comparison to an out-group member was 0.3 (as measured with the Cohen's d), which can be considered a medium effect size (Cohen, 1988). Similar results have been replicated in real-world settings as well. In cases where groups have been exposed to real war, such as the civil conflicts in Uganda (Bauer, Fiala, & Levely, 2017), Burundi (Voors et al., 2012), and Nepal (Gilligan, Pasquale, & Samii, 2014), participants from these groups were more likely to exhibit higher levels of effort after the end of the conflict, as measured through experimental games. Indeed, Bauer et al. (2016) identified 23 studies and used meta-analytical techniques on similar post-war societies to arrive to the same conclusions.

In sum, research has shown that the amount of effort exerted by players is affected by the problem type. Humans may have mechanisms to recognize an "us vs. them" collective action problem, e.g. a situation where the out-group is salient, and to increase their effort accordingly.

1.4.5 Gender and individual effort

The effects of gender on individual effort have been studied previously in many economic games, which have reviewed both the effect of gender on effort during collective action problems and how this effect is influenced by the type of problem ("us vs. them" vs. "us vs. nature"). Previous research is mixed when the collective action problem type is ignored. However, under "us vs. them" problems, male

individuals are expected to contribute more than female individuals.

Research suggests that female participants sometimes exert more effort during collective action problems (Aranoff & Tedeschi, 1968; Meux, 1973; Nowell & Tinkler, 1994), while in other cases male participants contribute more (Rapoport & Chammah, 1965; Brown-Kruse & Hummels, 1993). One consistent results across studies is that female participants are usually more altruistic, and in simple economic games, such as the dictator's game, female players are more willing to give part of their personal resources for the good of others (Andreoni & Vesterlund, 2001; Dreber, von Essen, & Ranehill, 2014; Brañas-Garza, Capraro, & Ramírez, 2018). However, based on a meta analysis of 272 experimental games, Balliet, Li, Macfarlan, and Van Vugt (2011) found that the gender effect may be conditional, as female participants exerted more effort in the prisoner's dilemma game, while in the public goods game the average effect size approached zero. In other words, whether females or males contribute more during collective action problem is still a contested question.

However, one conditional hypothesis regarding this problem is that "us vs. them" collective action problems have a preferential effect on the decision-making of males. This "male warrior hypothesis" poses that males are more likely to express biases based on their group affiliation in comparison to females, as they may have psychological mechanisms to form coalitions for inter-group conflict (McDonald, Navarrete, & Van Vugt, 2012). Indeed, in a set of three landmark studies, participants were told that they would play a type of public goods game. In one condition, groups of participants from one university were in competition with a group of participants from another university. The winner of the competition did not receive any prize for their accomplishment. The main finding from the study was that men contribute more toward the collective action problem's solution during competition, however the same effect was not observed in female participants (Vugt, Cremer, & Janssen, 2007). Comparative research also supports this idea, as in chimpanzees females rarely participate in aggressive between-group encounters, as in

92% of the cases the perpetrators of the attacks are male (M. L. Wilson et al., 2014).

In sum, previous research suggests that female participants are more altruistic. However, it is still unclear whether they are willing to exert more effort than males during collective action problems. One consistent conditional hypothesis, stemming from the theoretical literature, suggests that males exert more effort than females only during "us vs. them" collective action problems.

1.4.6 Cognitive processing and individual effort

Our cognitive system is designed to implement roughly two categories of processes in different situations: automatic and deliberative (Kahneman, 2011). The automatic processes (intuition) are fast, effortless and inflexible, while the deliberative processes (deliberation) are slower but flexible. Intuition is usually processed in parallel by the cognitive system, together with other processes, while deliberation takes the central stage and is processed in a serial manner. We are unconscious about the intuitive process through which we reach a decision, but when we reflect, we consciously come up with a proposed solution for a specific problem (Bear & Rand, 2016). It is important to note that the word "intuition" does not imply an evolutionary origin in this case. In fact, in many situations the intuition of a participant may be driven by cultural factors. Previous research suggests that the intuitive decision of players is to contribute in collective action problems, while their deliberative responses are to defect, especially when the strategic interaction with their groupmates is recurrent.

Indeed, in multiple experimental studies researchers have shown that humans may be intuitive contributors. For instance, Rand, Greene, and Nowak (2012) executed several experiments within the field of behavioural game theory, such as the prisoner's dilemma or the public goods game, to analyze this hypothesis. In a set of correlational studies, they found that players who reached their decisions faster in a public goods game were more likely to contribute to the common pool of resources.

To study further the causal effect of the decision speed, the authors introduced a paradigm to directly manipulate the decision time of participants. In this paradigm, some participants were asked to make their decision in under 10 seconds (time pressure), while other participants were asked to wait at least 10 seconds before they can make their decision (time delay). The results showed that participants in the time pressure treatment contributed on average more than participants in the time delay treatment. This finding was confirmed by a subsequent aggregate analysis from the same research group on 15 experiments (Rand & Kraft-Todd, 2014). Similar results, specifically with time constraint manipulations, were confirmed by other researchers in various experimental games, such as the ultimatum game (Sutter, Kocher, & Strauß, 2003; Cappelletti, Güth, & Ploner, 2011), the public goods (Cone & Rand, 2014), and the trust game (Neo, Yu, Weber, & Gonzalez, 2013).

In a novel meta-analysis encompassing 67 different studies, Rand (2016) revealed further nuances to this phenomenon. In his analytical framework, he categorized the type of problems an individual faces into two categories: pure or strategic. The pure problems are characterized by situations where there are few consequences for the players' actions. For example, in a simple Dictator's game, where one participant has to divide a spoil between himself and another participant, if there is a low probability that these two participants will meet again, the situation can be categorized as pure. In the behavioural game theory literature such situations are called "one shot" games (Camerer, 2003). The strategic problems are the opposite. There participant's decisions can have consequences, for example due to the repeated nature of their strategic interaction (e.g. two players matched on multiple occasions). Such games are also called "repeated" (Camerer, 2003). The findings from the meta study revealed that indeed the introduction of any form of intuition-inducing manipulation (such as time pressure vs. time delay) increases the contribution of subjects (Rand, 2016). However, in strategic or repeated problems there was no significant difference between intuition and deliberation in terms of effort.

In sum, research has shown that the processing speed of a contribution decision affects the outcome. In most cases, faster decisions lead to more effort (e.g. higher contributions). Both theoretical and empirical work suggests that this is the case only when the strategic situation is pure or one-shot.

1.5 Overview of research questions

In summary, I defined six research questions, which will be studied throughout this thesis.

1. **What is the effect of rank on individual effort during collective action problems?** In this case, one hypothesis that can be derived from the literature is that high-rank individual will exert more effort than low-rank individuals, especially during "us vs. them" collective action problems.

2. **What is the effect of rank on individual benefit during collective action problems?** For this question, I derive the so called altruistic bully hypothesis, which suggests that high-rank individuals may earn less than low-rank individuals, especially during "us vs. them" collective action problems.

3. **What is the effect of system type (hierarchy vs. egalitarianism) on group effort during collective action problems?** Based on the review of the literature in this chapter, a theoretical expectation that can be derived is that hierarchical groups will outperform egalitarian groups during "us vs. them" collective action problems.

4. **What is the effect of collective action problem type on individual effort?** Based on theoretical frameworks, such as parochial altruism, the hypothesis that can be derived for this question is that participants will contribute more during "us vs. them" than during "us vs. nature" collective action problems.

5. **What is the effect of gender on individual effort?** The main hypothesis for this question is the male warrior hypothesis, which suggests that male participants will contribute more than female participants during "us vs. them" collective action problems.

6. **What is the effect of cognitive processing speed on individual effort?** Regarding this question, both theoretical studies and previous empirical research suggest that the main hypothesis is that participants will exert more effort when making decision under time pressure than under time delay.

Questions 1-4 will form the primary questions of this thesis, while Questions 5-6 will be the secondary questions.

1.6 Thesis structure and contributions

The empirical portion of the thesis aims to test the aforementioned research question and to fill the gaps in the empirical literature through eight experiments in total, divided into two empirical chapters of four experiments each. All devised experiments employed contest game as a main empirical paradigm.

Chapter 2: Experiments with economic hierarchy This chapter aimed to study the aforementioned questions with economic hierarchy. This type of hierarchy, as operationalized in the studies, was based on individual income — e.g. individuals of higher rank in the hierarchy earned more, while individuals of lower rank earned less. In Study 1 UK participants played a contest game in controlled experimental settings, while in Study 2 US participants played a similar game in large-scale online settings. The main discoveries from these experiments were that during economic hierarchy, as expected, high-rank individuals contributed more than low-rank individuals. However, unexpectedly, egalitarian groups outperformed hierarchical groups in terms of group effort. Furthermore, these experiments revealed that tournaments, which can be seen as a type of "us vs. them" collective action problem, increase the contribution of players.

Chapter 3: Experiments with political hierarchy In this chapter hierarchy was defined in political terms, as some individuals (high-power players) were able to influence directly the decisions of other individuals (low-power players). The ability of one individual to influence another individual was defined as his/her power and served as a basis of his/her rank in the group. In this empirical chapter I studied the contribution preferences of players. Furthermore, I studied their resistance preferences, which were defined as their willingness to make personal sacrifice to resist the power of the high-power players. Study 3 was executed with US participants, playing a contest game with other US participants, while in Study 4 UK Christian participants or ethnic Bulgarian participants played the game with UK Muslim or ethnic Roma participants respectively. In this set of experiments the main discoveries were that the advantage of high-rank players in terms of contribution over the low-rank individuals was not significant, while in most cases the hierarchical groups actually outperformed the egalitarian groups.

Chapter 4: Meta comparisons To put all results in perspective, in Chapter 4 I executed a set of qualitative and quantitative meta-comparisons across all eight experimental studies (see Chapter 4). Furthermore, in some cases I included experiments done by other authors. The results of the meta-analyses outlined the main contributions of this thesis. The first main contribution is that in economic hierarchy high-rank players may contribute more than low-rank players, while in political hierarchy this may not the case. Second, groups with economic hierarchy exerted less effort than groups without such hierarchy (e.g. egalitarian), mainly due to a reduced contribution of the low-rank players. However, groups with political hierarchy usually exerted more effort than egalitarian groups. These findings suggest that the type of hierarchy is important, as it leads to different results in terms of contribution both at the individual- and at the group-level. The meta comparisons further revealed that the type of collective action problem (e.g. "us vs. them" vs.

"us vs. nature") is rarely influential for the contribution or resistance preferences of players. The gender of participants and the speed with which they were asked to make their decisions were not important factors for their relative contribution as well.

Chapter 5: General discussion In the final chapter I summarized all findings, outlined overarching methodological shortcomings of thesis and presented some fruitful areas for further researcher.

2

Experiments with economic hierarchy

2.1 Introduction

Many social animals, including humans, regularly engage in collective actions jointly with conspecifics to obtain or defend various resources. Collective actions can be broadly categorized into two types: "us vs. nature" and "us vs. them" (Gavrilets, 2014, 2015). "Us vs. nature" actions include collaborative efforts to secure resources from the environment, such as hunting, foraging, or jointly building or producing something. The "us vs. them" actions include direct competition and conflict between groups, for example, over food, territory, or mating opportunities. Both types of actions are observed in multiple species and are prevalent in human populations (Gavrilets, 2014, 2015).

Collective action can often lead to a collective action problem (Olson, 1965), which can be seen as a type of social dilemma, where there is a mismatch between

individual and collective interests (R. M. Dawes, 1980). Such problems are characterized by the fact that under some circumstances where individuals receive a part of the group's benefit independently of the level of their individual contribution, they may be better-off if they do not contribute to their group's success. For example, during war individuals may face a choice of active participation or defection. Active participation may help the group achieve its goal at hand (e.g. win the war), but this may reduce the individual's chances of survival, which leads to a strong incentive for free-riding. In many cases, however, people do not free-ride and choose to contribute, which has been pinpointed as one of the central puzzles of human evolutionary biology (Rand & Nowak, 2013).

Previous research has identified multiple mechanisms which can solve the puzzle, such as true altruism, reciprocity, reputation, internalized social norms, and third-party punishment (McElreath & Boyd, 2007; Nowak, 2006; Richerson & Boyd, 2005; Bowles & Gintis, 2011). In addition, recent theoretical and empirical advances within evolutionary biology have highlighted an additional factor: hierarchy (Gavrilets & Fortunato, 2014; Gavrilets, 2015; Gilby et al., 2015; M. L. Wilson et al., 2012; Zhuang et al., 2012).

This new focus can actually be traced back to Mansur Olson's "Logic of Collective Action" (Olson, 1965) who demonstrated through game theory modeling that in hierarchical groups dealing with "us vs. nature" collective action problems, the problem can often be solved due to the action of certain members (e.g. high-rank) who benefit the most. In such cases, other individuals (e.g. low-rank) are expected to free-ride and take advantage of the effort invested by high-rank group members, a phenomenon Olson called the "exploitation of the great by the small". Similar conclusions were made within the context of "us vs. them" actions (reviewed in Gavrilets (2015)). Moreover, under certain conditions (Gavrilets & Fortunato, 2014; Gavrilets, 2015), hierarchy is expected to increase group effort, especially when the collective action is of the "us vs. them" type. This effect is driven by increased

contributions of the high-rank individuals. As a result, hierarchical groups can solve the "us vs. them" collective action problems better than egalitarian groups.

Surprisingly, as a result of their high effort (and, consequently, high cost paid), high-rank group members may, under some conditions (e.g. strong between-group competition), end up with lower net benefit than their low-rank groupmates. This happens because the latter free-ride and do not pay the costs of participation in the collective action. In effect, high-rank individuals behave as if they were altruistic. This phenomenon was coined the altruistic bully effect (Gavrilets & Fortunato, 2014). What makes the high-rank individuals contribute disproportionally more is not altruism but rather that they effectively compete against high-rank individuals in other groups.

Additionally, recent theoretical work has shown that groups engaged in "us vs. them" collective actions are expected to produce more effort than those facing "us vs. nature" challenges, especially when group penalties are a factor (Gavrilets & Fortunato, 2014; Gavrilets, 2014). This idea is congruent with various theories within evolutionary biology, such as the theory of parochial altruism (Choi & Bowles, 2007), which stresses the significance of inter-group competition for individual effort (McElreath & Boyd, 2007; Nowak, 2006; Richerson & Boyd, 2005; Bowles & Gintis, 2011).

Primary goals and previous findings. The goal of the chapter is to test whether the aforementioned theoretical expectations are part of the behavioural repertoire of human subjects in a series of experimental games. In all experiments, hierarchy was defined in economic terms, as rank was based on differences in income. More specifically, I defined four research hypotheses: (**H1**) high-rank players will contribute more than low-rank players during "us vs. them" collective action problems, (**H2**) high-rank players will earn less than low-rank players during "us vs. them" problems, and (**H3**) hierarchical groups will contribute more than egalitarian

groups during "us vs. them" problems. Moreover, participants are expected to contribute more during "us vs. them" problems than during "us vs. nature" problems (**H4**), which was measured in two different ways. First, I manipulated the type of contest from being an inter-group contest vs. control contest. Second, I introduced a type of tournament condition, called group penalty, where the worst performing group, out of all groups currently in the study, was penalized. Both the inter-group contests and the group penalty conditions were a type of "us vs. them" collective action problems, as groups competed directly against other groups for resources. The control conditions and the lack of group penalty condition were seen as "us vs. nature" collective action problems, because in these conditions groups did not compete against each other directly. See the methods section for each experiment for further details.

Some of these research hypotheses have been previously studied individually in the experimental literature. Most experiments with public goods games, with one exception (Buckley & Croson, 2006), indicate that both with and without between-group conflict, high-rank players contribute more than low-rank players (Fisher et al., 1995; Chan et al., 1996; Reuben & Riedl, 2009; Sheremeta, 2011; Doğan et al., 2018). However, the second hypothesis, namely that high-rank individuals will earn less than low-rank individuals during "us vs. them" problems, has not been explicitly tested. Public goods games in "us vs. nature" settings have demonstrated that in some cases hierarchical groups outperform egalitarian groups (Chan et al., 1996; Reuben & Riedl, 2009), while in other cases the results are reversed (Bagnoli & McKee, 1991; Rapoport & Suleiman, 1993). When "us vs. them" problems are involved, the results were also mixed (see Gunnthorsdottir and Rapoport (2006); Kugler et al. (2010) for stronger performance of hierarchical groups and Ke (2011) for stronger performance of egalitarian groups). Finally, previous studies have demonstrated that the introduction of "us vs. them" problems or a group elimination (penalty) process, in the form of between-group competition,

increases the average effort of players (Puurtinen & Mappes, 2009; Burton-Chellew et al., 2010; Burton-Chellew & West, 2012; Egas et al., 2013; Dechenaux et al., 2015).

General methods I devised four behavioural economics experiments within a simple yet general framework where players make independent decisions about the size of their costly contributions toward the group's success. The framework is based on the contest paradigm, a modified version of the public goods game, which adds a probabilistic component to the strategic situation (Dechenaux et al., 2015). In the baseline version of the experimental paradigm, used in this thesis, participants were divided into groups of four players. Players in each group were asked to decide on a contribution (x_i) they wanted to make. The total contribution (X_i) was the sum of all individual contributions:

$$X_i = \sum_{k=1}^{N} x_i \tag{2.1}$$

where N is the number of players in the group (set to four).

In some cases, each group currently in the experiment was assigned to play a contest against another randomly selected group. In each pair, the group with higher total contribution (X_i) had a higher chance to win the contest and to receive a prize. More specifically, the probability of contest win for the focal group (P_i) was defined as:

$$P_i = \frac{X_i}{X_i + X_j}, \tag{2.2}$$

where X_j is the total contribution of the opponent of the focal group, calculated with the same method as X_i (see eq. (2.1))

In the setup, I manipulated the system type. In some experiments, groups were egalitarian, i.e. all members received an equal share of the prize. In other experiments, the groups were hierarchical, so that some members received a bigger

share of the reward than others. Furthermore, across all experiments, I manipulated whether the contest was reminiscent of an "us vs. them" or "us vs. nature" collective action, e.g. whether the there was out-group salience or not. The aforementioned variables were manipulated in a different way across the four experimental studies (see the corresponding Methods sections for each experiment).

I measured the contribution decision of each player (x_i) and the corresponding net benefit (π_i). The net benefit was the remainder of the pot after the contribution decision of the individual (x_i), plus the share of the contest prize. In some experiments, the share of the contest prize was the same for all participants (egalitarian groups), while in other experiments the share of the prize differed between participants (hierarchical groups). In all experiments the contest prize size was set to 300 monetary units.

To analyze the results I used the same analytical technique across all experiments. Namely, I constructed a linear mixed-effects model (LME) (Gelman & Hill, 2006) for the contribution preferences and net benefits of players. Furthermore, I used a group-level comparison between different experiments to analyze the effect of hierarchy on group contribution (see Section 2.2.3 for Study 1 and Section 2.3.3 for Study 2).

Secondary goals I further explored several secondary research questions. First, in all experiments I included a dual-processing manipulation. I asked participants to make their decisions under time pressure, which varied between experiments. Some earlier work suggests that this manipulation will lead to more contributions (Rand, 2016), because individuals are expected to be "intuitive" contributors and to defect only when given some time to think (Bear & Rand, 2016; Rand, 2016). Furthermore, I used the gender of participants as a quasi-independent variable in all statistical models. This allowed me to investigate whether some of the effects are gender-specific. Previous research has argued that males should be better in solving "us vs. them" collective action problems, due to their psychological

instincts for alliance formation (Vugt et al., 2007; McDonald et al., 2012) — a theory know as the male warrior hypothesis.

Definition of economic hierarchy As mentioned, in this chapter I have selected a concrete definition of economic hierarchy, based on income. More specifically, high-rank players are defined as participants who are to earn more from the contest prize, if the prize is won. Conversely, low-rank players are earning less from the prize. There are several alternative definitions of economic hierarchy, with their corresponding issues. For example, an often used definition in many theoretical papers is the proportional redistribution of the contest prize relative to the effort of the player. The higher the effort of the individual, the higher the proportion of the prize (see Gunnthorsdottir and Rapoport (2006) for an example). The problem with this definition is that it is too strong — the player not only increases his/her group's chance of winning the contest through his/her effort but also increases his expected earnings from the game. Therefore, this definition of economic hierarchy is strongly susceptible to profit maximization biases. Participants invest more only because they will earn more. An alternative definition is based on the wealth of the individuals. In such games, high-rank players have a bigger endowment than low-rank players (see Rapoport and Suleiman (1993) for an example). This operational definition of rank is susceptible to a different problem, the so called lose aversion bias, which suggests that people are more likely to act in a way to reduce their loses than to increase their earnings (Kahneman & Tversky, 1979; Tversky & Kahneman, 1991). The income-based definition of economic hierarchy, used in this thesis, also has flaws, as participants are again susceptible to a profit maximization bias, as their behaviour may be driven by their willingness to increase their income. However, this susceptibility is weaker than the proportional definition of economic hierarchy and does not trigger additional proximate mechanisms, such as the lose aversion bias. Further to this argument, my decision to concentrate my

effort on income-based hierarchy has been driven by my willingness to design the setup of the experiments as close as possible to the setup of the central theoretical models, used as a basis for this thesis, which also use definitions of hierarchy based on differences in the expected evolutionary fitness gain of the agents (Gavrilets & Fortunato, 2014; Gavrilets, 2015).

Overview of results With respect to the hypotheses listed above, the main findings from the studies are mixed. I discovered that in all cases higher-rank players contributed more than lower-rank players, which was in line with the predictions. However, this over-contribution did not lead to a relative reduction in terms of net benefits, as higher-rank usually earned more than lower-rank players. This result may be explained by the way the experimental paradigm stacks the odds against the hypothesis, as high-rank players, earning more than their low-rank counterparts, need to exhibit an extreme degree of relative contribution in order to earn disproportionately less. Unexpectedly, egalitarian groups contributed more than hierarchical groups in most cases. Finally, I found that while group penalty increases individual contributions, the type of contest (inter-group vs. control contests), time constraint, and gender did not affect significantly the contribution preferences of players. Overall, the findings contribute to the evolutionary literature on collective action problems as they demonstrate that (i) effort changes as a function of rank, (ii) group effort is dependent on the level of hierarchy, and (iii) group penalty increases the effort of players.

2.2 Study 1

Study 1 aimed to determine whether, and how, contributions and net benefits of players varied as a function of the type of collective action problem faced by the group ("us vs. them" vs. "us vs. nature") and the system type. The study

comprised two experiments, one featuring hierarchical groups (Experiment 1a), the other featuring egalitarian groups (Experiment 1b).

The study was executed in a laboratory setting at the Nuffield Centre for Experimental Social Sciences (CESS) in Oxford, with samples drawn from the CESS participants database. The experiments were executed with the z-Tree platform for economic experiments (Fischbacher, 2007). Each experiment comprised six experimental sessions, with 16 participants per session.

The sample for Experiment 1a consisted of 96 participants, while the sample for Experiment 1b consisted of 96 participants. General methods for both experiments are presented in Appendix A.1, while the analytical framework used in all experiments is presented in Appendix A.2.

2.2.1 Experiment 1a

Methods

For each experimental session, 16 participants were invited to the laboratory and played 16 periods of a contest game, corresponding to the possible combinations of three within-subject independent variables: player type, group penalty, and time constraint (Figure 2.1), described below.

In each period, participants were randomly assigned to one of four groups. Within each group, the four participants were randomly assigned a rank. Each period comprised three rounds, and participants maintained their rank across them. At the beginning of each round, participants were assigned an endowment of 120 monetary units. In all cases, the contest prize was set to 300 monetary units. Participants received feedback about the outcome of each contest and their reward in monetary units.

Before the first period, participants read instructions, participated in a short quiz, and played a training round. Contrary to many subsequent experiments in this

dissertation, the quiz was not used as a comprehension test. Quiz questions were projected to participants and they were asked to think of answers by themselves. Shortly after, the answers were projected and participants were encouraged by the research assistant to raise any questions or concerns. Thus, the actual answers to the quiz questions were not recorded during the experimental session.

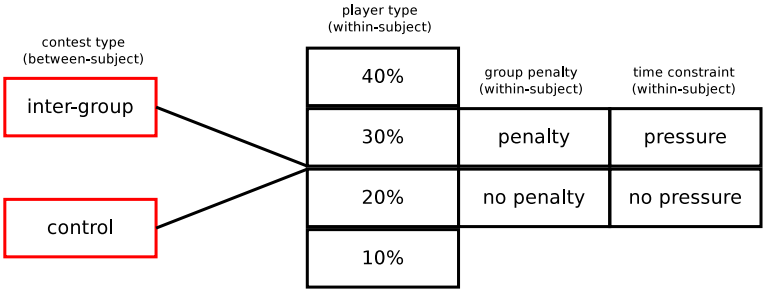


Figure 2.1: Graphical representation of the experimental design of Experiment 1a. Contest type was a between-subject variable with two treatments. Therefore, participants were split randomly to play one of the two contest types at the beginning of the experiment. Player type, group penalty, and time constraint were within-subject variables with 16 treatment combinations in total.

Contest type Half the experimental sessions involved *inter-group* contests, half involved *control* contests. In the inter-group contest condition, the four groups were randomly matched into two pairs, so that at the end of the three rounds in a period every group would have played all other groups. In each round, the pair of groups played a contest game, as described in eq. (3.2).

In the control contest condition, there was no pair-wise matching of groups. Rather, groups played the contest game against a computer-generated value of total contribution. Specifically, the probability of contest win for the focal group, P_i, can be expressed as:

$$P_i = \frac{X_i}{X_i + X_n} \tag{2.3}$$

where X_n is the computer-generated value, which was unknown to players in the group. Thus, as in the theoretical definition of "us vs. nature" collective action

problems, this condition does not have the inter-group conflict component, typical of "us vs. them" problems (Gavrilets, 2014, 2015). The value of X_n was taken randomly from the distribution of values of X_j produced during a previous experimental session featuring inter-group contest games.

The inter-group contest condition can be seen as a prototypical "us vs. them" collective action problem, as participants combine their effort to win the contest against another group. This is equivalent to multiple real-world situations, such as sport teams playing against each other, two businesses trying to win customers, and, even, although with the assumption that the net benefit in this abstracted setup is indicative of evolutionary fitness, to inter-group confrontations in the real word, such as war or raiding behaviour, which are observed in both chimpanzees and hunter-gatherer groups (Wrangham & Glowacki, 2012; M. L. Wilson et al., 2014; Glowacki et al., 2017).

The control contests are abstractions of the "us vs. nature" collective action problems, as groups aim to solve the problem without competing directly against another group. In this cases, psychological proximate mechanisms for inter-group competition should not be activated. These situations are similar to cases where the group, for instance, has to exert group effort to construct a building, or to forage for resources in the environment. In such cases, participants do not know what is the possible danger (e.g. what they are facing), but still have to exert the group effort to finish the task. Similarly, participants in the control contest are told only that "the more they contribute, the higher the chance to win the contest", thus effectively reducing the salience of their "opposition".

Player type In each period, participants in a group were randomly assigned a *player type* or rank, based on the fraction of the contest prize — 40%, 30%, 20%, or 10% — they would receive if their group won the contest.

This definition of hierarchy, as based on income, can be seen in many cases

where people work together in the group, but the degree of income inequality is high. For example, in a business organization, some members of the team earn more, despite the fact that the success of the company may depend on all employees. Similarly, during war, some individuals may earn more of the spoils than others, based on their rank in the group.

Group penalty In half of the periods, participants played under *group penalty*. Given that each period consisted of three rounds, at the end of a group penalty period the four groups were arranged in descending order, based on their total contribution over the three rounds. The group with the lowest total contribution was penalized by losing all earnings from the period, with a 50% probability. Group penalty was not implemented in the other half of the periods.

This variable is analogical to real world cases where multiple groups are in a direct competition for a prize. For example, in a company, multiple teams may have to comply to various key performance indicators, such as a number of sales or produced income, while the team with lowest performance may be penalized, for instance with salary reductions.

Contest type, group penalty, and collective action In the case of this experiment, following the definitions of "us vs. them" and "us vs. nature" collective action problems, presented in Chapter 1, the case where either group penalty or inter-group contest have been applied can be seen as an "us vs. them" collective action problem. As explained, the contest type variable was manipulated between subjects, with two levels, while the group penalty variable was manipulated within subjects, again with two levels. This makes four possible treatment combinations: (i) group penalty with inter-group contests, (ii) group penalty with control contests, (iii) no group penalty with inter-group contests, and (iv) no group penalty with control contests. Of these situation, the first three can be seen as "us vs. them" collective

action problem cases, as groups were playing either the contest against another group, or in a tournament with all other groups. The only combination of the two variables, which can be seen as analogical to an "us vs. nature" collective action problem, is the fourth, as the groups were not competing against another group in any way.

Time constraint In half of the periods, participants made their decisions under *time pressure* of six seconds. Time pressure was not implemented in the other half of the periods.

Materials for Experiment 1a are presented in Appendix A.3.

Participants and power analysis The sample for Experiment 1a consisted of 96 participants (Male = 46; Female = 44; Other = 6), with a mean age of 29.67 years, ranging from 18 to 65 years old ($SD = 12.08$).

The sample size was determined based on financial and logistics constraints. A power analysis indicates that for all dependent variables the design has a power of $\beta \geq 0.8$ at $\alpha = 0.05$ for an effect size of ≥ 0.51 for the contest type variable, ≥ 0.17 for the player type variable, and ≥ 0.36 for the time constraint and group penalty variables. Thus, the design is slightly underpowered to capture a small effect size for the contest type variable.

Results and discussion

For each of the two dependent variables (contribution and net benefit), I constructed only one model which fits the maximal fixed- and random-effects structure, as justified by the experimental design (Barr, Levy, Scheepers, & Tily, 2013). Thus, the slopes and intercepts of all variables, which were measured within-subjects (e.g. with repeated measures), were nested in the participants variable. As suggested by other researchers, in all cases I simplified the random structure of the model by removing the interactions and correlations between the random slopes, which

reduced the number of estimated parameters and allowed me to optimize the models without convergence errors (Singmann & Kellen, 2017) and to increase their power (Barr et al., 2013; Matuschek, Kliegl, Vasishth, Baayen, & Bates, 2017). The p-value for all results were approximated following the Kenward-Roger method (Kenward & Roger, 1997). To explore interaction effects, I executed a set of post-hoc comparisons for each model, based on the estimated marginal means (EMM) (R. V. Lenth et al., 2016), with a Tukey multiple comparisons adjustment (Tukey, 1949). In all cases, when participants have not made their decisions within the allotted time frame in the time pressure conditions, such decisions have been removed from the model. The number of removed decisions was 155 or 3.36% of all decisions. The removed decisions were not imputed. This methodological approach was used in all experiments. A more elaborate explanation of the analytical framework is presented in Appendix A.2. Full results from the models and estimated marginal means (EMM) comparisons can be seen in Appendix A.4.

The LME model of contributions revealed a statistically significant main effect of rank, F(3, 91.96 = 45.1), $p < 0.001$, $R^2_{sp} = 0.08$. Participants contributed 59.83 monetary units ($SD = 34.81$) when they were to receive 40% of the prize, 53.26 monetary units ($SD = 34.13$) when they were to receive 30% of the prize, 41.59 monetary units ($SD = 35.7$) when they were to receive 20% of the prize, and 34.07 monetary units ($SD = 34.72$) when they were to receive 10% of the prize. The variable was not involved in a significant interaction, thus, the hypothesis that higher-rank individuals contribute more than lower-rank individuals (**H1**) was supported.

In terms of net benefits, the LME model revealed a main effect of player type as well, F(3, 91.94) = 15.02, $p < 0.001$, $R^2_{sp} = 0.03$. Participant earned 116.36 monetary units ($SD = 54.55$) when they were to receive 40% of the prize, 106.37 ($SD = 47.2$) when they were to receive 30% of the prize, 102.77 ($SD = 45.49$) when they were to receive 20% of the prize, and 94.13 ($SD = 40.24$) when they were to receive 10% of the prize. An EMM comparison further revealed that higher-rank

players earned more than or as much as lower-rank players in all combinations of the contest type and group penalty variables. Thus, the altruistic bully hypothesis (**H2**) was not supported by the data, as lower rank players did not earn more than higher-rank players in any case.

The LME model of contributions revealed that players contributed more monetary units under group penalty ($M = 54.94$, $SD = 34.49$) than without group penalty ($M = 39.43$, $SD = 36.26$), $F(1, 94) = 70.95$, $p < 0.001$, $R^2_{sp} = 0.05$. Group penalty was involved in a statistically significant interaction with contest type, $F(1, 94) = 5.47$, $p < 0.021$, $R^2_{sp} = 0.004$, which did not alter qualitatively the results for any of the two variables, based on an EMM comparison. Thus, the introduction of group penalty unconditionally increased the contribution preferences of players. Based on this, the hypothesis that "us vs. them" problems increase contributions to the group's success (**H4**) is partially supported by the data, as only the group penalty variable produced a significant effect. The other group salience manipulation was not effective. Furthermore, time constraint and gender did not influence the preferences of participants in a significant way.

In sum, as seen in Figure 2.2, the models suggest that players of higher rank contribute more than players of lower rank. However, this did not result in smaller net benefits for higher-rank players in comparison to lower-rank players. The introduction of group penalty increased the contribution preferences of participants, while contest type, time constraint, and gender did not change the behaviour of participants.

2.2.2 Experiment 1b

Methods

Experiment 1b replicated closely the procedure and variables of Experiment 1a (see Figure 2.3). The only difference between the two experiments was that participants

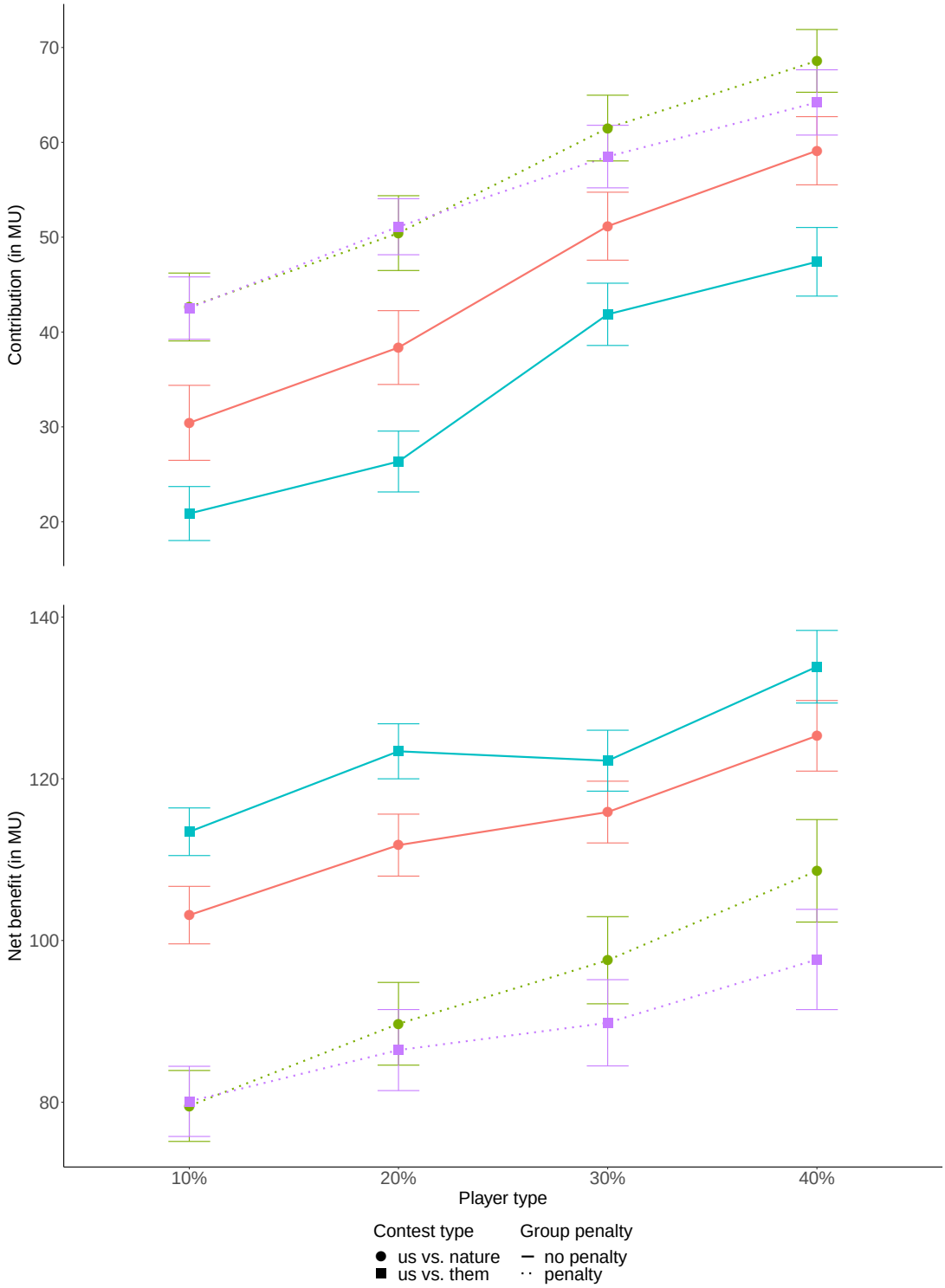


Figure 2.2: Experiment 1a: Contribution and net benefit by player type and each combination of the contest type and group penalty variables. Player type increases contribution and net benefit. Group penalty increases contribution and decreases net benefit. Error bars represent one standard error.

did not play the game in hierarchical groups. In all cases, groups were egalitarian. This means that if the group wins the prize in a contest, it is divided equally between participants. Therefore, the number of periods in each experimental sessions was four, as this represents all possible combinations of the two within-subject variables: group penalty and time constraint. In each period, participants again played three rounds. Furthermore, players were given an initial endowment of 75 monetary units for each of their decisions. I changed the endowment of players from 120 monetary units in Experiment 1a to 75 monetary units. The rationale stemmed from the fact that the maximum possible reward from the prize for each player was 75 monetary units (or $\frac{300}{4}$), thus a contribution of more than 75 monetary units (e.g. more than the expected maximum reward) is irrational and highly unlikely, as it will bear more cost than possible benefit. Full materials for Experiment 1b are presented in Appendix A.5.

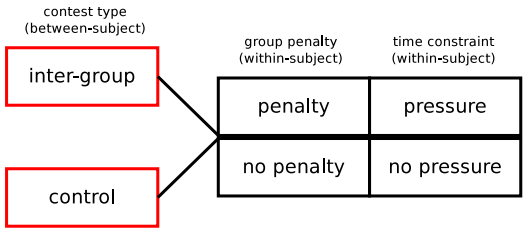


Figure 2.3: Graphical representation of the experimental design of Experiment 1b. Contest type was a between-subject variable with two treatments. Therefore, participants were split randomly to play one of the two contest types at the beginning of the experiment. Group penalty and time constraint were within-subject variables with four treatment combinations in total.

Participants and power analysis The sample for Experiment 1b consisted of 96 participants (Male = 42; Female = 52; Other = 2), with a mean age of 28.15 years, ranging from 18 to 68 years old (SD = 11.51).

The sample size was determined based on financial and logistics constraints. A power analysis indicates that for all dependent variables the design has a power of $\beta \geq 0.8$ at $\alpha = 0.05$ for an effect size of ≥ 0.51 for the contest type variable and ≥ 0.36 for the time constraint and group penalty variables. Thus, again, the design again

was slightly underpowered to capture a small effect size for the contest type variable.

Results and discussion

I executed LME models for all dependent variables of interest. Full results from the models and estimated marginal means (EMM) comparisons can be seen in Appendix A.6. Decisions that did not comply to the time constraint during time pressure manipulations were removed. The number of removed decisions was 41 or 3.56% of all decisions.

The LME model of contributions (Figure 2.4) revealed that the group penalty variable produced the only statistically significant main effect, $F(1, 93.98) = 48.3$, $p < 0.001$, $R^2_{sp} = 0.08$. Participants contributed more monetary units with a group penalty ($M = 44.93$, $SD = 20.84$) than without a group penalty ($M = 31.45$, $SD = 23.81$). Group penalty was involved in a significant 2-way interaction with contest type, $F(1, 93.98) = 7.6$, $p < 0.007$, $R^2_{sp} = 0.01$. However, based on an EMM contrasts comparison, the main effect of group penalty was not conditional on the contest type variable.

To sum up, only the group penalty variable was a significant factor which affected the contribution preferences of players. Thus, the hypothesis that "us vs. them" collective action problems increase contribution (**H4**) is again partially supported by the data, as only this form of group salience was effective. As in Experiment 1a, contest type, time constraint, and gender did not affect the contribution of players.

2.2.3 Group-level comparison between Experiment 1a and Experiment 1b

As the endowments of player in Experiment 1a and Experiment 1b were different (120 vs 75 monetary units respectively), I aggregated each group's total contribution (X_i) relative to its total endowment (e_i). The quotient from $\frac{X_i}{e_i}$ is the group's

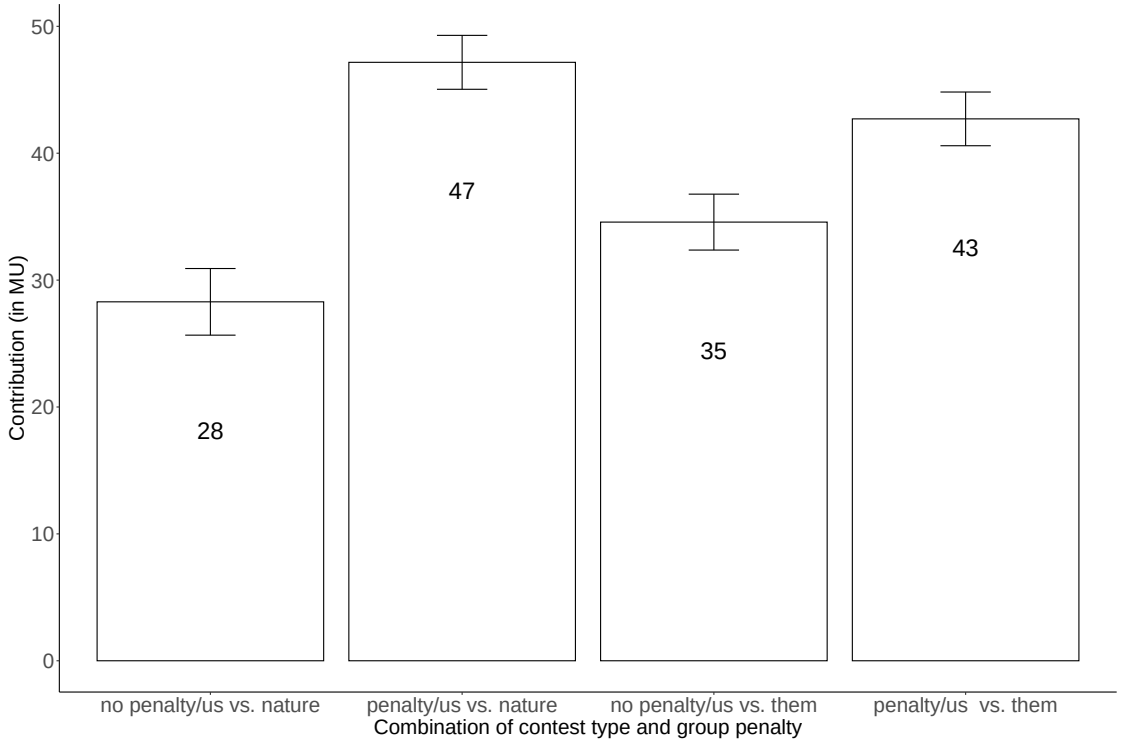


Figure 2.4: Experiment 1b: Contribution per contest type and group penalty. Only group penalty increses contribution. Error bars represent one standard error.

contribution as a percentage of its endowment. This allowed me to compare directly the relative difference in terms of contribution between the hierarchical groups in Experiment 1a and the egalitarian groups in Experiment 1b (e.g. *system type*). The full model can be seen in Appendix A.7.

A power analysis for the group comparison in Study 1 indicates that the design has a power of $\beta \geq 0.8$ at $\alpha = 0.05$ for an effect size of ≥ 0.23 for the contest type, system type, time constraint, and group penalty variables.

A between-subject ANOVA analysis (Figure 2.5) based on the group-level data revealed that there was indeed a statistically significant main effect of system type, $\mathrm{F}(1, 464) = 48.67$, $p < 0.001$, $\eta_p^2 = 0.09$. Egalitarian groups contributed a bigger percentage of their endowment ($M = 50.81\%$, $SD = 18.82\%$) than hierarchical groups ($M = 39.07\%$, $SD = 15.88\%$). However, the system type variable was involved in a statistically significant 3-way interaction with contest type and group penalty, $\mathrm{F}(1, 464) = 10.42$, $p < 0.001$, $\eta_p^2 = 0.02$. An EMM comparison revealed that

egalitarian groups did not outperform hierarchical groups only in control contests without group penalty, p = n.s. In all other cases egalitarian groups reached higher total contribution than hierarchical groups.

Thus, the effect of system type was conditional on the type of problem faced by the group. Taken together, these findings did not support the hypothesis that hierarchical groups will outperform egalitarian groups (**H3**). In most cases, egalitarian groups outperformed hierarchical groups.

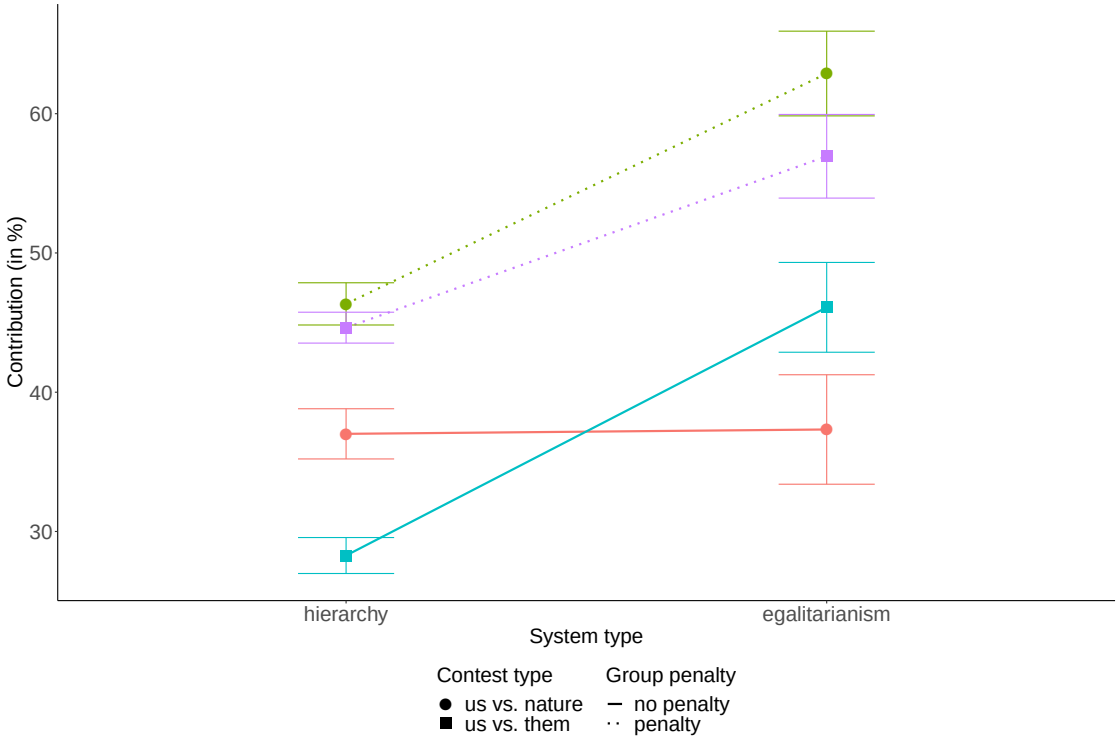


Figure 2.5: A group-level comparison of contributions for hierarchical (Experiment 1a) and egalitarian (Experiment 1b) groups per contest type and group penalty. Egalitarian groups contribute more than hierarchical groups in all cases, except during "us vs. them" problems without group penalty. Error bars represent one standard error.

2.3 Study 2

The goal of Study 2 was to replicate findings from Study 1 with a bigger and more diverse sample. The study again comprised of two experiments, one featuring hierarchical groups (Experiment 2a), the other featuring egalitarian groups

(Experiment 2b).

Study 2 was executed online with the survey platform Qualtrics with a sample from Amazon's Mechanical Turk service. All participants were from the United States. The sample for Experiment 2a consisted of 331 participants, while the sample for Experiment 2b consisted of 380 participants.

General methods for both experiments are presented in Appendix B.1, while the analytical framework used in all experiments is presented in Appendix B.3.

2.3.1 Experiment 2a

In Experiment 2a all groups were hierarchical, thus I was able to see whether the findings from Experiment 1a are replicated with a different sample of online participants.

Methods

Experiment 2a used similar variables as Experiment 1a (see Figure 2.6). The contest type variable was operationalized in the same way, while the player type, group penalty, and time constraint variables were modified, which allowed me to test the consistency of the findings from Experiment 1a under slightly different operational constraints.

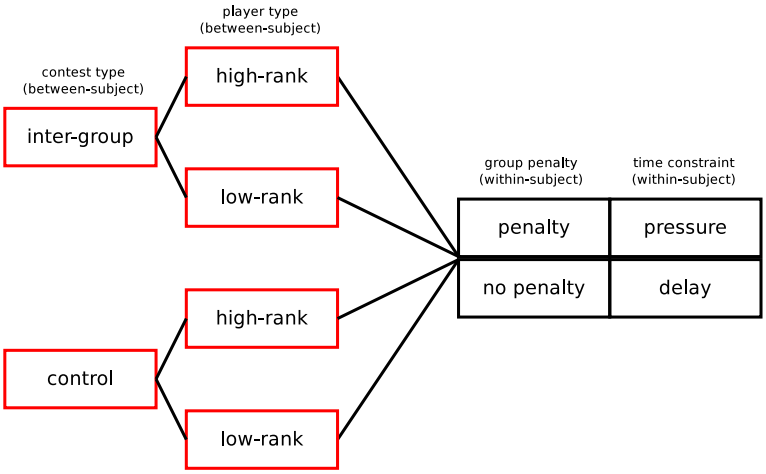


Figure 2.6: Graphical representation of the experimental design of Experiment 2a. Contest type and player type were between-subject variables with two treatments each. Therefore, participants were split randomly to play one of the two contest types and to one of the two ranks at the beginning of the experiment. Group penalty and time constraint were within-subject variables with four treatment combinations in total, while contest type was a between-subject variable.

Contest type As in Study 1 participants were randomly divided to play either inter-group contests or control contests. In inter-group contest participants' groups were randomly matched to play against another group, while during control contests there was no such matching process.

Player type In terms of player type, players were assigned to be either high-rank or low-rank, based on their performance in an irrelevant task (see Appendix B.4). Therefore, contrary to Experiment 1a, this variable was manipulated between subjects.

Group penalty The group penalty variable was modified in such a way that, after the ranking of the four groups in a descending order based on their total contribution, only the 1st group had no chance of being penalized, while the other three groups received a probability inversely proportional to their rank. The 2nd group received a 25% chance of being penalized, the 3rd group received a 50% chance, and the 4th group received a 75% chance. If a group was penalized, all

its members lose all of their earnings.

Time constraint Finally, the time constraint variable was modified by introducing time pressure (asking participants to make their decisions within a 10 seconds window) vs. time delay (asking participants to wait for at least 10 second before they can make their decisions).

Participants read the experimental instructions, were assigned a contest type and player type, and played four rounds of a contest game, each for a prize of 300 monetary units. Players were given an endowment of 120 monetary units for each of their contribution decisions. The four contest games represent all possible combinations of the two within-subject variables: group penalty and time constraint.

In this experiment all participants were asked to make their decisions under the aforementioned four scenarios and did not receive any feedback about the outcome of each contest or their earnings. To calculate the net benefits of players from each contest game, I developed a Monte Carlo simulation. The simulation uses all decisions of players as an input and samples the distribution of possible outcomes for each decision over multiple iterations. I used the mean of the distribution (e.g. the expected net benefit) as a dependent variable for all net benefit LME models in Experiment 2a. The simulation logic, together with an extended rationale, is presented in Appendix B.2. Moreover, full materials for Experiment 2a are presented in Appendix B.4.

Participants and power analysis For Experiment 2a I recruited 394 participants. Of these participants, 63 were removed as they were unable to answer at least two of the comprehension questions from the quiz correctly. Therefore, the sample for Experiment 2a consisted of 331 participants from the United States, recruited through the Amazon's Mechanical Turk service (Male = 161; Female = 170), with a mean age of 38.41 years, ranging from 18 to 80 years old (SD = 12.3).

The sample size was determined based on financial and logistics constraints. However, I aimed to increase the sample signficantly in comparison to Experiment 1a, which has an equivalent design. A power analysis indicates that for all dependent variables the design has a power of $\beta \geq 0.8$ at $\alpha = 0.05$ for an effect size of ≥ 0.27 for the contest type variable, ≥ 0.17 for the player type variable, and ≥ 0.19 for the time constraint and group penalty variables.

Results and discussion

I executed LME models for all dependent variables of interests. Full results from the models and estimated marginal means (EMM) comparisons can be seen in Appendix B.5. Decisions that did not comply to the time constraint during time pressure manipulations were removed. The number of removed decisions was 67 or 5.06% of all decisions. The removed decisions were not imputed.

Based on the LME model of contributions, there was a significant difference between the two ranks, $F(1, 323.08 = 39.77)$, $p < 0.001$, $R^2_{sp} = 0.08$. High-rank players contributed more monetary units ($M = 69.85$, $SD = 34.38$) than low-rank players ($M = 48.88$, $SD = 37.07$). As the player type variable was not involved in a significant interaction, **H1** was supported by the data.

This difference in contribution between the two ranks led to higher expected net benefit for the high-rank players in comparison to the low-rank players, contrary to the altruistic bully hypothesis, $F(1, 279.74) = 76.09$, $p < 0.001$, $R^2_{sp} = 0.14$. High-rank players earned significantly more monetary units ($M = 87.66$, $SD = 32.16$) than low-rank players ($M = 68.04$, $SD = 35.81$). Based on an EMM comparison, the patterns was the same across all combinations of the contest type and group penalty variables ($p > 0.05$). Thus, **H2** was not supported by the data.

Moreover, the LME model of contributions revealed a main effect of group penalty, $F(1, 323.49) = 69.37$, $p < 0.001$, $R^2_{sp} = 0.03$. As in all previous experiments, players contributed more monetary units with group penalty ($M = 67.62$, $SD =$

36.56) than without group penalty ($M = 54.46$, $SD = 37.45$). Contest type, however, did not change significantly the contributions of players. Thus, as in Study 1, **H4** was partially supported, as only group penalty increased contribution.

In terms of secondary questions, the main effect of gender was not statistically significant in the contribution model. However, an exploratory EMM comparison revealed that the effect of gender was significant only in cases when players were playing an inter-group contest with group penalty, t(321.92) = 2.46, $p < 0.014$, $d = 0.8$. In such cases, female participants contributed more monetary units ($EMM = 73.78$, $SE = 3.58$) than male participants ($EMM = 61.32$, $SE = 3.58$).

To sum up (see Figure 2.7), as in Experiment 1a, I found that high-rank players outperformed low-rank players under all combinations of the group penalty and contest type variables. However, this difference did not lead to higher expected earnings for the low-rank players, as they earned less than their high-rank counterparts. Group penalty was again a significant factor which increased the contribution preferences of players. Contest type and time constraint did not produce any significant main effects, but a novel exploratory result was that female participants seem to contribute more than male participants during inter-group contests with group penalty.

2.3.2 Experiment 2b

Methods

Experiment 2b replicated closely the procedure and conditions of Experiment 2a with egalitarian instead of hierarchical groups (see Figure 2.8). Therefore, participants again played four rounds of a contest game, which represented the four possible combinations of the two within subject variables: group penalty and time constraint. Participants were given an endowment of 75 monetary units for each decision, as this was the maximum possible earning from the prize. Therefore, any contribution

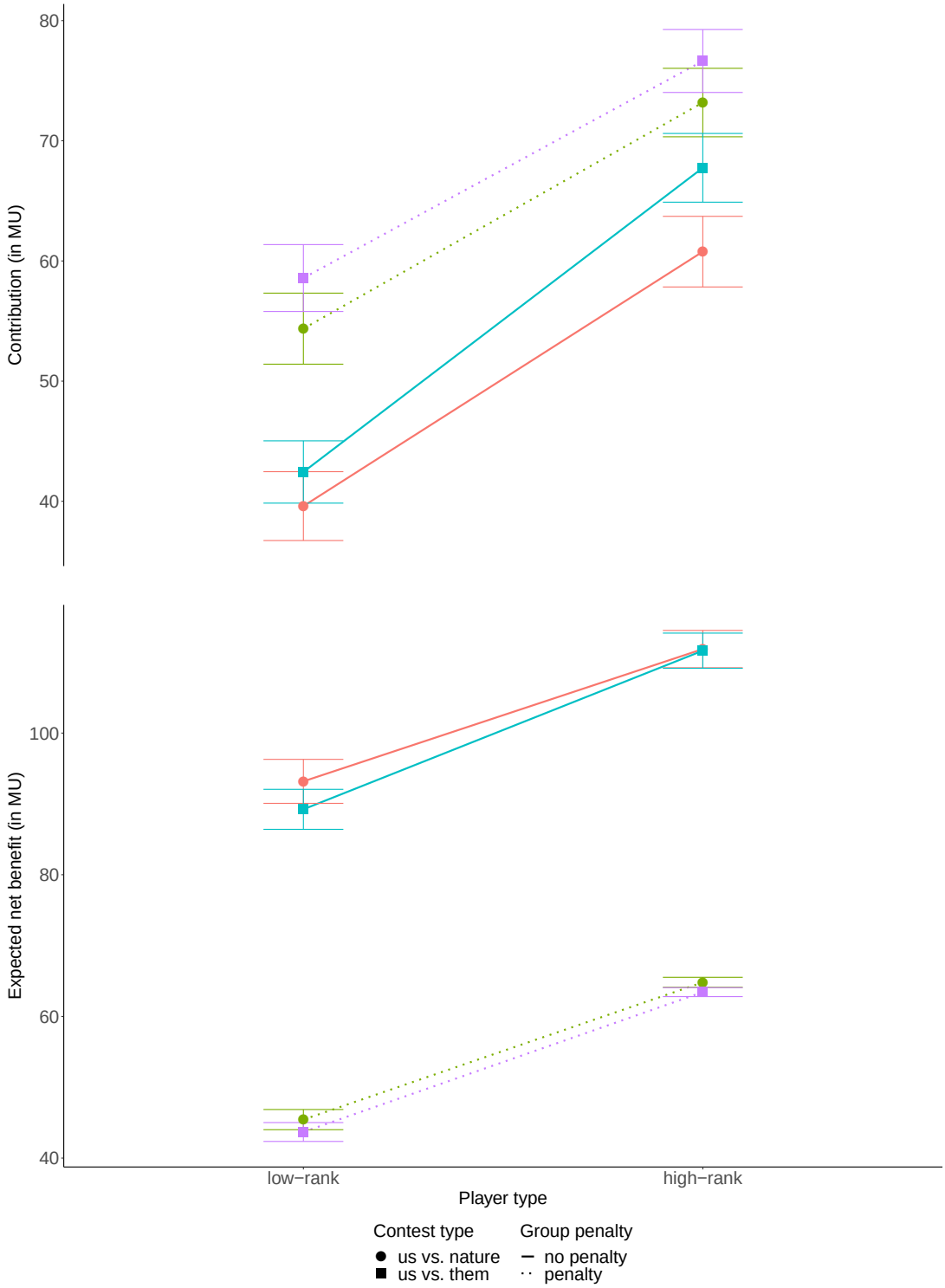


Figure 2.7: Experiment 2a: Contribution and net benefit by player type and each combination of the contest type and group penalty variables. Player type increases contribution and net benefit. Group penalty increases contribution and decreases net benefit. Error bars represent one standard error.

higher than 75 monetary units is expected to bear for sure more cost than benefit and is highly unlikely. Full materials for Experiment 2b are presented in Appendix B.6.

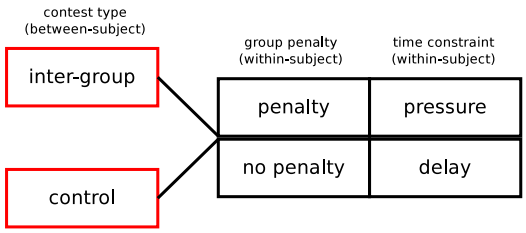


Figure 2.8: Graphical representation of the experimental design of Experiment 2b. Group penalty and time constraint were within-subject variables with four treatment combinations in total.

Participants and power analysis For Experiment 2b I recruited 404 participants. Of these participants, 24 were removed as they were unable to answer at least two of the comprehension questions from the quiz correctly. Therefore, the sample for Experiment 2b consisted of 380 participants (Male = 166; Female = 214), with a mean age of 38.29 years, ranging from 18 to 79 years old ($SD = 12.57$).

The sample size was determined based on financial and logistics constraints. However, I aimed to increase the sample signficantly in comparison to Experiment 1b, which has an equivalent design. A power analysis indicates that for all dependent variables the design has a power of $\beta \geq 0.8$ at $\alpha = 0.05$ for an effect size of ≥ 0.26 for the contest type variable, and ≥ 0.18 for the time constraint and group penalty variables.

Results and discussion

I executed LME models for all dependent variables of interests. Full results from the models and estimated marginal means (EMM) comparisons can be seen in Appendix B.7. Decisions that did not comply to the time constraint during time pressure manipulations were removed. The number of removed decisions was 78 or 5.13% of all decisions. The removed decisions were not imputed.

Based on the LME model of contributions (Figure 2.9), the only statistically

significant main effect related to group penalty, F(1, 375) = 78.96, $p < 0.001$, R^2_{sp} = 0.03. With group penalty participants contributed more monetary units (M = 50.68, SD = 22.43) than without group penalty (M = 42.62, SD = 23.69).

In sum, **H4** was partially supported by the data, as only group penalty was a significant variable, while contest type, time constraint, and gender did not change the contribution preferences of players.

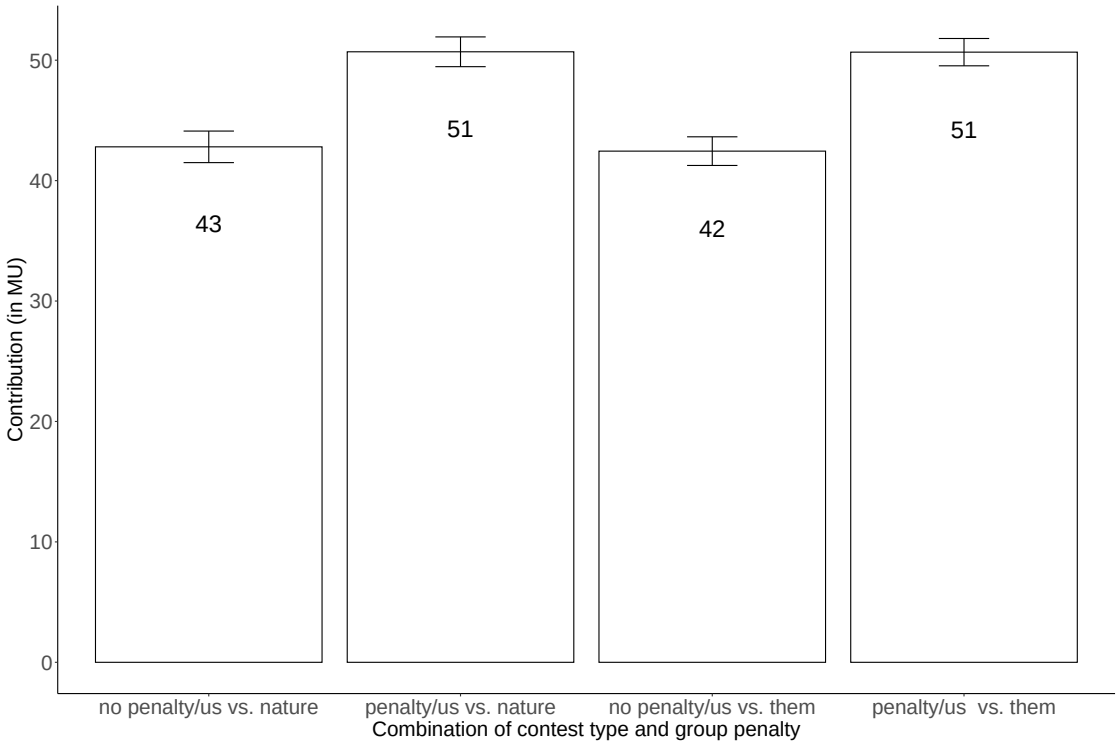


Figure 2.9: Experiment 2b: Contribution by contest type and group penalty. Only group penalty increses contribution. Error bars represent one standard error.

2.3.3 Group-level comparison between Experiment 2a and Experiment 2b

As in Study 1, I calculated each group's total contribution (X_i) relative to its total endowment (e_i). The full model can be seen in Appendix B.7.

A power analysis for the group comparison in Study 2 indicates that the design has a power of $\beta \geq 0.8$ at $\alpha = 0.05$ for an effect size of ≥ 0.23 for the contest

type and system type, and an effect size of ≥ 0.16 for the time constraint and group penalty variables.

A mixed-ANOVA analysis (Figure 2.10) revealed that there was a statistically significant difference between the two system types, $F(1, 160) = 50.74$, $p < 0.001$, $\eta_p^2 = 0.24$. As in Study 1, egalitarian groups contributed a bigger percentage of their endowment ($M = 61.72\%$, $SD = 15.93\%$) than hierarchical groups ($M = 50.82\%$, $SD = 15.96\%$). Based on an EMM comparison, this was the case under all combinations of the contest type and group penalty variables ($p < 0.05$).

Thus, **H3** was not supported by the data. This is similar to the findings from Study 1, where egalitarian groups outperformed hierarchical groups in all cases, with the exception of control contests without group penalty.

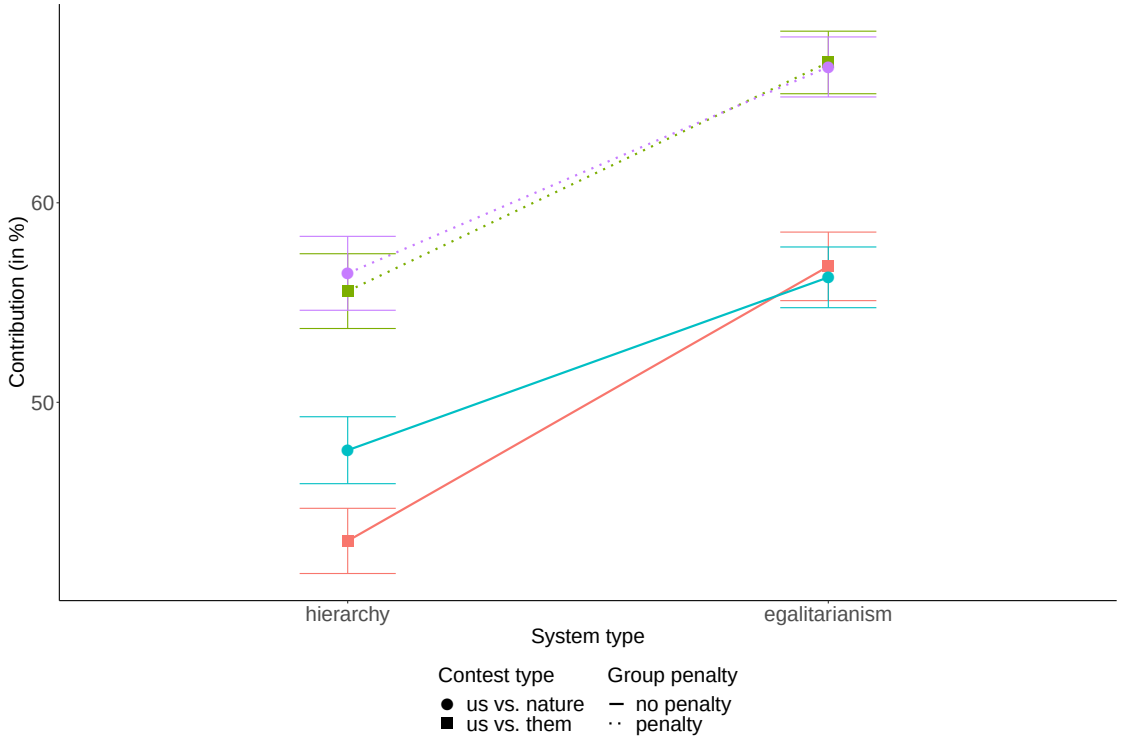


Figure 2.10: Group-level comparison of contributions for hierarchical (Experiment 2a) and egalitarian (Experiment 2b) groups per contest type and group penalty. Egalitarian groups contributed more than hierarchical groups in all cases. Error bars represent one standard error.

2.4 Discussion

In this section I will discuss in more detail the findings from Chapter 2 (e.g. Study 1 and Study 2). A general meta-discussion of all findings from all experiments, including limitations and suggestions for future research, can be found in the final part of the thesis (i.e. Chapter 5).

2.4.1 Findings

The findings from both studies with regards to the main research hypotheses are summarized in Table 2.1.

Hypothesis	Study 1	Study 2
H1: High-rank contribute more than low-rank during "us vs. them"	Yes	Yes
H2: High-rank benefit less than low-rank during "us vs. them"	No	No
H3: Hierarchical groups contribute more than egalitarian during "us vs. them"	Reverse supported	Reverse supported
H4: More contribution during "us vs. them" than during "us vs. nature"	Partially	Partially

Table 2.1: Results from Study 1 and Study 2 for each of the research hypotheses

Primary findings

High-rank players contribute more than low-rank players in all cases The first hypothesis (**H1**) which I defined for both Study 1 and Study 2 was that high-rank individuals will contribute more than low-rank individuals in hierarchical groups during "us vs. them" collective action problems. A consistent finding from both studies was that high-rank players, who earned higher share from the prize in the contest, contributed more during "us vs. them" collective action problems. Thus, **H1** was supported in both studies.

Results from Study 1 and Study 2 are in line with theoretical predictions within economics (Olson, 1965) and evolutionary biology (Gavrilets & Fortunato, 2014; Gavrilets, 2015). In previous theoretical work, Olson (1965) has predicted that

when hierarchical groups solve collective action problems, all agents who earn less (low-rank players) will free-ride, while agents who earn more (high-rank players) will be the sole contributors in the group. Other work by Gavrilets and Fortunato (2014) has further supported the conclusions made by Olson by extending his results to "us vs. them" collective action problems. Moreover, most public goods and contest experiments have found similar results, especially when rank is based on income (Fisher et al., 1995; Chan et al., 1996; Sheremeta, 2011).

This result suggests one possible mechanism through which hierarchical groups may be beneficial for some players. If high-rank individuals contribute more than low-rank individuals, this effort mismatch may lead to increase in the expected returns of low-rank players, which may make hierarchy functional.

It is important to note that the difference between high- and low-rank players was the case under all types of collective action problems (e.g. "us vs. them" and "us vs. nature"), which suggests that, at least with this form of hierarchy (economic), the effects of the economic system type was not dependent on the collective action problem type. Furthermore, in economic hierarchy it is hard to differentiate whether the findings are mainly driven by the fact that (i) high-rank players have a preference to contribute more than low-rank players, (ii) that they contribute more because they will earn more when their group wins, or (iii) both. In some of the upcoming experiments (see Chapter 3), I will study how the contribution preferences of players change as a function of a different form of hierarchy — political hierarchy. In this form of hierarchy, the rank differences were based on the ability of one player (a high-power individual) to influence the decisions of another player (a low-power individual). Thus, differences between player ranks were not based on income, and, if high-power players contribute more, this cannot be explained with profit maximization. The findings from these upcoming experiments, as seen in Chapter 3, are that under political hierarchy players' rank does not influence their contribution decisions, which hints at a conditional effect of rank on contribution

as a function of the type of hierarchy.

High-rank players earn more than low-rank players in most cases. The second research hypothesis (**H2**) was that high-rank participants will benefit less than low-rank participants during "us vs. them" collective action problems. As groups in both Study 1a and Study 2a were hierarchical, this allowed me to test this theoretical prediction. In both experimental studies, when individuals who earn 40% of the prize and individuals who earn 10% of the prize were compared, the results demonstrated that the 40% players earn significantly more than the 10% players. The result from Study 2a is stronger than the result from Study 1a because of the introduction of a Monte Carlo simulation to calculate the expected net benefits of players, which minimizes the effect of random factors in the assignment and matching process. Thus, **H2** was not supported by the data.

The result is novel to the experimental literature, where the altruistic bully effect has not been studied explicitly. It contradicts theoretical predictions made by Gavrilets and Fortunato (2014) which suggest that high-rank individuals will earn relatively less than low-rank players during "us vs. them" collective action problems. Based on their rationale, the reduced benefits are a function of significant contributions the high-rank players (which was observed in the experiments). When groups play against other groups, the hierarchy leads to contrasting contribution preferences. Low-rank players are expected to contribute very little (which was not observed in the experiments), while high-rank players were expected to take the entire burden of contribution. As collective action problems represent social dilemmas, an increase of contribution usually leads to a decrease in benefits (R. M. Dawes, 1980). Thus, high-rank players were expected to earn less than low-rank players due to their increased contribution.

One potential reason for these discrepancies between theory and experiments is the specific setting of the game, which may have been stacked against the altruistic

bully effect. In economic hierarchy, as defined in Study 1 and Study 2, participants who are of a higher rank benefited more from the game in comparison to low-rank players, as they earned a bigger percentage of the prize. Therefore, in such cases high-rank individuals should contribute significantly more than low-rank individuals in order to earn significantly less. The more extreme the difference, the higher the chance of an altruistic bully effect appearing in the results.

If such income discrepancies are removed, for example with a different definition of hierarchy, high-rank individuals may still contribute significantly more than low-rank individuals, but at the same time earn significantly less. One possible way to mitigate the issue is by using a different definition of economic hierarchy, namely one based on difference in endowment (not in income). In such cases, high-rank individuals have bigger pots than low-rank individuals, thus higher contribution may be achieved by using a smaller chunk from one's own endowment. I did not use this approach for two reasons. First, the income-based definition of hierarchy resembles more closely the theoretical models developed by Gavrilets and collaborators. Thus, I wanted to keep a degree of resemblance between the theoretical setup and the empirical paradigm. Second, the operational definition of the net benefit of players used in all experiment is just the remainder of the pot after the contribution decision of the individual, plus the share of the contest prize. Therefore, if players are given bigger pots, their net benefit is expected to be bigger, which will again stack the odds against the altruistic bully hypothesis. To mitigate this issue, in Chapter 3 I introduced political hierarchy. In this type of hierarchy, players of different ranks do not receive different income or endowment. This political setup was expected to produce more extreme differences and help make the altruistic bully effect more pronounced. However, as seen in this next chapter, the results from these experiments suggest that low-rank individuals do not earn more than high-rank individuals, even under political hierarchy.

Egalitarian groups contribute more than hierarchical groups in most cases. The third research hypothesis (**H3**) was that hierarchical groups will contribute more than egalitarian groups during "us vs. them" problems. However, in both Study 1 and Study 2 egalitarian groups outperformed hierarchical groups during "us vs. them" collective action problems. The only difference between the two experiments was that in Study 1 there was no statistically significant difference between the two system types only during control contests without group penalty. Thus, **H3** was not supported by data. In fact, the reverse hypothesis was supported.

This finding contradicts some of the predictions stemming from the theoretical models discussed in Chapter 1. Based on them, hierarchical groups are better suited to solve "us vs. them" collective action problems than egalitarian groups. There are several mechanisms which may cause the stronger performance of hierarchical groups, including the fact that such group structure "motivates" individuals to contribute, helps groups resolve internal conflict, introduces centralized punishment, reduces the cost of contribution, and increases coordination through leadership. However, this seems not to be the case, at least with income hierarchy. Most of the aforementioned benefits of hierarchy are bound to some forms of political hierarchy, and, at least in this experimental paradigm, the only mechanism which potentially could give an advantage of hierarchical groups over egalitarian groups is the fact that high-rank individuals may contribute to a greater extent and thus boost the group's total contribution, as predicted by theoretical models (Olson, 1965; Gavrilets & Fortunato, 2014). Despite the fact that in most cases high-rank players contributed significantly more than low-rank players, this contribution was not sufficient to overcome the the low contribution levels of the latter.

Previous results from other collective action experiments were mixed. Some findings suggested that hierarchical groups out-perform egalitarian groups in public goods games (Chan et al., 1996; Reuben & Riedl, 2009), in contest games (Gunnthorsdottir & Rapoport, 2006; Kugler et al., 2010), and in team performance

studies (C. Anderson & Brown, 2010). The results from both Study 1 and Study 2 suggest a different picture, as in most cases egalitarian groups contribute more than hierarchical groups.

Based on my knowledge, only two previous experiments in contest games have reached similar results as Study 1 and Study 2. Indeed, in a set of contest games, Ke (2011) showed that when players earn a share of the prize proportional to their benefits, this reduces their group contribution in comparison to receiving equal earnings from the prize. More recently, Doğan et al. (2018) executed a contest game in lab-in-the-field experimental settings in the South Omo Valley of Ethiopia with Nyangatom, Daasanach, and Highland Ethiopian participants. Participant played the same two-group Tullock contest which was used both in Study 1 and in Study 2. Players formed ethnically homogeneous groups and played the game either against a group with which they have an antagonistic relationship (e.g. Nyangatom vs. Daasanach) or a neutral relationship (e.g. Nyangatom vs. Highland Ethiopian). One of the main results from the study, similar to findings from Study 1 and Study 2 of this thesis, was that individuals of high-rank, who earned a bigger share of the prize, were willing to contribute more toward the group success than were low-rank individuals. Moreover, only individuals in egalitarian groups were affected by the contest type (e.g. antagonistic vs. neutral group). Players in egalitarian groups contribute more than all other players when the opponent was antagonistic than when the opponent was neutral. This result is similar to the one observed in Study 1, where egalitarian groups contributed more than hierarchical groups in all "us vs. them" collective action problem treatment combinations. However, in Study 2 egalitarian groups outperformed hierarchical groups in the "us vs. nature" condition as well.

One possible explanation for this result may be connected to the proximate decision-making mechanisms of human participants. For example, previous research with human and primate participants has demonstrated preferences for economic fairness (Fehr & Schmidt, 1999, 2000, 2010; Rabin, 1993; Brosnan & De Waal,

2003). In the ultimatum game, where one player had to split a reward between himself and another player, the first player was more likely to make a fair split (50% for each player) and, when asked, the second player was more likely to reject unfair splits (Oosterbeek, Sloof, & Van De Kuilen, 2004). Thus, one possible explanation for the increased performance of egalitarian groups in comparison to hierarchical groups may be that participants found the hierarchical situation to be economically unfair, which reduces their effort toward the group's success. A second possible proximate mechanism which can explain the results is the economic inequality aversion preferences of players. Previous results in the experimental literature suggest that when participants are given a random endowment, participants with a bigger endowment were willing to increase the resources of participants with smaller endowment, while participants with a smaller endowment were willing to decrease the resources of participants with a bigger endowment. This result has been observed both with adult (C. T. Dawes, Fowler, Johnson, McElreath, & Smirnov, 2007) and with child subjects (Blake et al., 2015). Thus, a second possibility is that participants reduce their contribution to express their aversion toward unequal distribution of resources. In some of the follow-up studies in Chapter 3 I further investigated whether these findings are replicated under a different form of hierarchy, based on political power. Furthermore, I aimed to explore whether the degree of economic hierarchy leads to higher levels of resistance by participants. Results from these upcoming experiments suggest that under political hierarchy hierarchical groups indeed outperform egalitarian groups under some circumstances. This again hints at the conditional nature of this effect as a function of the type of hierarchy (political or economic).

Only group penalty but not contest type influenced the contribution decisions of players. The final research hypothesis (**H4**) was that participants will contribute more during "us vs. them" collective action problems than during "us

vs. nature" collective action problems. The effect of "us vs. them" collective action problems on contribution was consistent in both studies. I manipulated whether the context was equivalent to an "us vs. them" or an "us vs. nature" problem by changing systematically two variables: contest type and group penalty. During contest type manipulations groups either played against other groups or against the computer, thus the only difference was the psychological expectation of playing against a real group of players — e.g. the out-group salience. In group penalty manipulations groups were penalized as a function of their total contribution, with groups with lower total contribution receiving a higher probability of losing their earnings. Based on the results from both Study 1 and Study 2, the group penalty variable was more influential in comparison to the contest type variable.

This finding is in line with several theoretical positions within evolutionary biology and psychology. For instance, the theory of parochial altruism (Choi & Bowles, 2007; Bowles, 2009) posits that humans exhibit an increased contribution with in-group members during "us vs. them" problems because of the multi-level selection pressures during our evolutionary history. If we assume that humans have evolved in group settings, members of groups which fail in "us vs. them" collective action problems may have a reduced evolutionary fitness (Bowles, 2009). The inter-group bias of players has been explained at the proximate level by psychological theories as well (Tajfel, 1982; Yamagishi, Jin, & Kiyonari, 1999). This finding is in line with previous behavioural research which shows in-group favoritism across multiple laboratory experiments (Hewstone et al., 2002; Everett, Faber, & Crockett, 2015) and real-world studies (Bauer et al., 2016). As the group penalty condition can be seen as a rank-order tournament, this result echoes findings from other experimental studies, which suggest positive effects of real and pseudo tournaments on within-group contribution (Burton-Chellew et al., 2010; Burton-Chellew & West, 2012).

An interesting finding was that the increase in contribution was observed only

in the group penalty conditions, which suggests that competition with monetary incentives may have a stronger effect than a simple group salience manipulation (e.g. whether the contest is against a real group or not).

One possible explanation may have to do with the fact that both experiments were slightly underpowered. Indeed, a power analysis indicates that the design has a power of $\beta \geq 0.8$ at $\alpha = 0.05$ for an effect size of ≥ 0.26 for the contest type variable for both experiments in Study 1. To mitigate this issue, in Study 2 I increased significantly the sample size by utilizing a population of online participants and replicated the same findings. Another possible explanation for this result, other than the existence of a contribution in-group bias during "us vs. them" problems, is that this behaviour may be based on the humans' loss aversion preferences. Previous research has shown that human participants prefer not to lose something than to win something (Tversky & Kahneman, 1991). As in the group penalty variable, some group members were losing all their earnings from the prize, if their group was penalized, their increased contribution may be triggered by their unwillingness to lose resources. Another possible explanation is that the contest type manipulation has been too weak, and thus unable to activate the possible parochial altruism of players. Both studies have arguably a low ecological validity, due to the artificial pattern of group formation. Both experiments were set in minimal groups settings (Tajfel, 1982), as all groups were formed randomly, without any history of conflict. Such experiments are usually considered a weak manipulation which produces small effect sizes, if any. In some of the forthcoming experiments I will use a stronger manipulation to further investigate this conjecture. In Chapter 3, two experimental studies used a more extreme form of inter-group conflict. For instance, in Study 4a, I explored the effects of religious antagonism on contribution (e.g. UK Christian vs. UK Muslim players), while in Study 4b I explore the effect of ethnic antagonism (e.g. ethnic Bulgarian vs. ethnic Roma players) on contribution. However, results from these experiments suggest that the effect is not there. Neither with minimal groups,

nor with real groups the effect size is not sufficiently large. Therefore, this suggests that the effect of the collective action problem type on contribution is not sufficient.

Secondary findings

There was no effect of gender on contribution in almost all cases. One exploratory direction I took was to study the effects of gender on contribution. Across both experimental studies in this chapter gender did not influence the contribution preferences of players in almost all cases. Male participants did not contribute more than female participants in both Study 1 and Study 2.

This contradicts the theoretical prediction that the in-group bias in contribution is specific to male participants. The rationale behind the prediction stems from the so called male warrior hypothesis, developed in evolutionary psychology (Vugt et al., 2007; McDonald et al., 2012). According to this idea, inter-group conflict represents a strong selection pressure for males, which shapes their psychological mechanisms for aggression and alliance formation (Vugt et al., 2007). Males who are part of aggressive raiding groups usually have a higher probability to gain access to mates and resources, thereby increasing their reproductive success.

Interestingly, based on an exploratory analysis in Study 2a, female participants contributed more than males during "us vs. them" collective action problems (e.g. under inter-group contests and group penalty). Based on my knowledge, this result has not been predicted by the theoretical literature. Thus, I am unable to offer an interpretation. However, to verify the finding, I included the gender of participants as an independent variable in the models of all upcoming experiments in this thesis (Chapter 3). Unfortunately, neither of these upcoming studies did not support the male warrior hypothesis directly, and did not show a stronger contribution bias of the female participants.

There is no effect of decision making speed on contribution. A second exploratory research direction I took was to study the effect of time constraint on contribution. In both Study 1 and Study 2 the effect of time pressure was not statistically significant. In Study 1, I compared time pressure vs. no time pressure, while in Study 2 I compared time pressure vs. time delay. There was no effect of this variable in any of the experiments.

The result contradicts some of the previous findings on intuition and deliberation. The contest game paradigm presented in this chapter can be seen as a "pure" strategic situation. In both Study 1 and Study 2, the decisions of all participants were anonymized. Furthermore, when a group was matched against another group during inter-group contests, participants were not told which players were their enemies. Thus, the situation can be considered "pure", as no groups knew if they were playing with the same group repeatedly. The expectation in "pure" strategic situations is contribution differences between intuition and deliberation. This is based on both theoretical predictions (Bear & Rand, 2016) and on previous empirical results (Rand, 2016). Namely, based on these results, when intuition is involved, participants are expected to contribute more, while when the time pressure is reduced, participants were expected to contribute less. Both Study 1 and Study 2, however, were unable to replicate the findings. In both experimental studies intuition did not lead to changes in contribution.

This result may be specific to contest games or to the sample of participants used in the experiment. First, based on my knowledge, this cognitive processing paradigm has not been applied previously in contest games. The second suggestion, however, is especially plausible as the sample in Study 2 was drawn from Mechanical Turk participants, which have been shown to be insensitive to common manipulations as a function of their experience (Rand et al., 2014). However, the results from Study 1 suggest that this may not be the case, as participant there were not coming from the Mechanical Turk workforce. To investigate whether the lack of

significant effect replicates, I incorporated the time constraint manipulation in all remaining experiments of this thesis. Results from these upcoming experiments, however, suggests that the effect is not there.

2.4.2 Conclusions

In conclusion, the study of hierarchical and egalitarian groups in "us vs. them" collective action problems yielded several novel findings and replicated several previous results from the experimental literature. In hierarchical groups, high-rank players contributed more than low-rank players. The altruistic bully hypothesis, as proposed by Gavrilets and Fortunato (2014), was not supported by the results in both experimental studies. Unexpectedly, egalitarian groups usually out-performed hierarchical groups in terms of contribution. The introduction of a group penalty, which can be seen as a rank-order tournament contest, increased the contribution of participants. Males did not contribute more than females in "us vs. them" games. If anything, in Study 2a, females contributed more in such cases. Finally, both intuition and deliberation led to similar levels of contribution.

3

Experiments with political hierarchy

3.1 Introduction

Many social organisms, including humans, engage in collective action over resources, such as hunting, foraging, or warfare. Such collective action presents individual group members with a social dilemma — whether to incur costs by contributing to the greater good of the group or to free-ride (R. M. Dawes, 1980). Collective action problems can be roughly divided into two categories — "us vs. them" problems and "us vs. nature" problems. The first problem type involves competition or conflict against another group, while the second problem type involves collaborative effort to secure resources from the environment. (Gavrilets, 2014, 2015). The problem of group effort during such collective action problems has been coined the central issue of evolutionary biology (Rand & Nowak, 2013), and has been supposedly solved by multiple proposed theories and mechanisms, such as altruism, reciprocity, reputation,

internalized social norms, and third-party punishment (McElreath & Boyd, 2007; Nowak, 2006; Richerson & Boyd, 2005; Bowles & Gintis, 2011). In this chapter, I will continue my study of this issue by again proposing hierarchy as a novel additional factor which can solve the problem (Gavrilets & Fortunato, 2014; Gavrilets, 2015; Gilby et al., 2015; M. L. Wilson et al., 2012; Zhuang et al., 2012). Indeed, previous theoretical research suggests that hierarchical groups may outperform egalitarian groups during collective action, due to the willingness of the high-rank individuals in such groups to contribute significantly more than the low-rank individuals (Olson, 1965). It has been theorized that this phenomenon is particularly pronounced during "us vs. them" collective action problems (Gavrilets & Fortunato, 2014; Gavrilets, 2015). Interestingly, as a result of the high effort of high-rank individuals, under "us vs. them" problems with strong between-group competition, such individuals may end up with lower relative net payoff than their low-rank groupmates, a phenomenon called the altruistic bully effect (Gavrilets & Fortunato, 2014).

In Chapter 2, I studied these propositions with economic hierarchy based on income. Results showed that, in such cases, high-rank players indeed contribute more than their low-rank counterparts. However, surprisingly egalitarian groups outperformed hierarchical groups in most cases, while low-rank players did not earn more than their high-rank counterparts.

The main goal of the current chapter is to extended these findings by introducing the concept of political hierarchy, based on power. Power can be viewed as the ability to impose one's will on others (French, Raven, & Cartwright, 1959). It was strictly defined by Dahl (1957) as: "Individual A has power over individual B to the extent that he can get B to do something that B would not otherwise do". In more formal terms, power (M) can be defined as the probability of response (p_1) by the subordinate given an action by the powerful individual minus the probability of response (p_2) given no action by the powerful individual (e.g. $M = p_1 - p_2$) (Dahl, 1957). This measurement can be used to compare the relative power of

different individuals, all things being equal. Other authors have provided similar definitions of power (Forsyth, 2009). Therefore, in groups with political hierarchy the difference of rank is not based on income or any other valuable social dimension, but on relative power of one individual over all other individuals in the group.

The concept of power is closely related to the concept of resistance. Indeed, a novel goal of this chapter is to study how resistance is affected by the collective action problem type faced by group members. Resistance can be viewed as the preference to reduce the influence of more powerful individuals through reducing personal benefits.

The definition of resistance is equivalent to real-world situations, where individuals may be willing to make a personal sacrifice, such as going on a hunger strike or engaging in a direct confrontation, in order to reduce the hierarchy's influence over them. For instance, during mass protest movements, many individuals prefer to risk their lives in order to fight the ability of the high-rank individuals (the politicians) to influence them. In hunter-gatherer societies, as shown by (Boehm, 1999), many low-rank individuals prefer to risk their evolutionary fitness by imposing various leveling mechanisms on the high-rank individuals and directly challenging them. Some of their approaches to do so include deposition, desertion, exile, and even execution.

As discussed in Chapter 1, research from hunter-gather and chimpanzee groups suggests a nuanced picture regarding the resistance preferences of humans. The leveling mechanisms imposed on high-rank group members may be seen as direct challenges against high-rank individuals (Boehm, 1999). At the same time, they may not resist hierarchy in specific situations, especially when it is necessary and/or when they are unable to fight it directly (Boehm, 1999; Murdock & White, 1969), for example during war (Binford, 2001; Hooper et al., 2010). As previously discussed in Chapter 1, evolutionary models of human group effort suggest that hierarchical groups may be able to outperform egalitarian groups during "us vs. them" collective action problems in evolutionary time (Gavrilets & Fortunato, 2014; Makowsky & Smaldino, 2016). Hierarchical social systems present a distinct advantage in

comparison to egalitarianism, by "adding" more tools to the group's arsenal, such as motivation for contribution, resolution of internal conflict, reduction of the cost of punishment and contribution, and better coordination through leadership. Therefore, one possibility is that such problems can potentially change human hierarchy preferences. When the problem is "us vs. them", humans may be less resistant toward hierarchy; in such cases hierarchy may result in better group performance (Van Vugt et al., 2008) and may increase individual benefit.

Primary goals and previous findings In this chapter, I define five research hypotheses. First, I expected that high-rank participants will contribute more (**H1**) and will benefit less (**H2**) than low-rank individuals in hierarchical groups during "us vs. them" collective action problems. Second, I expected that hierarchical groups will contribute more than egalitarian groups during "us vs. them" collective action problem (**H3**). Finally, I expected that participants will contribute more (**H4**) and will be less resistant (**H5**) during "us vs. them" collective action problems than during "us vs. nature" collective action problems or less severe "us vs. them" problems.. The contest type variable was manipulated in various ways across all experiments, by contrasting group salience vs. no group salience, inter-group contest difficulty, and in-group vs. out-group contests.

Previous research has experimentally tested these hypotheses. In public goods games and contest games, high-rank players usually exert more effort than low-rank players (Fisher et al., 1995; Chan et al., 1996; Reuben & Riedl, 2009; Sheremeta, 2011; Doğan et al., 2018), but there is not enough experimental research suggesting that they will earn less (Gavrilets & Fortunato, 2014; Gavrilets, 2014). On top of that, the research regarding which system type will perform better during collective action problems is mixed, as some experiments suggest better results for hierarchical groups (Chan et al., 1996; Reuben & Riedl, 2009; Gunnthorsdottir & Rapoport, 2006; Kugler et al., 2010), while others suggest better results for egalitarian groups

(Bagnoli & McKee, 1991; Rapoport & Suleiman, 1993; Ke, 2011), both during "us vs. them" and "us vs. nature" collective action problems. The introduction of "us vs. them" problems, which are more extreme, usually increases contribution in collective action problem games (Puurtinen & Mappes, 2009; Burton-Chellew et al., 2010; Burton-Chellew & West, 2012; Egas et al., 2013; Dechenaux et al., 2015). Interestingly, most of the aforementioned experiments are based on economic instead of political hierarchy.

Additionally, the main novel hypothesis in this chapter has to do with the effect of the collective action problem type on resistance. As discussed, hierarchical groups are expected to outperform egalitarian groups, especially during "us vs. them" collective action problems. In such circumstances, as the system type presents a benefit for the individual, they may have conditional changes in their preferences, which may lead to less resistance to hierarchy during "us vs. them" problems than during "us vs. nature" problems.

Previous research regarding this effect is mixed and/or incomplete. On the behavioural level, research from experimental games indirectly demonstrates the plausibility of the hypothesis. In a seminal experimental study involving a public goods game, De Cremer and Van Vugt (1999) assigned each player to a group, and each group had to make a certain amount of contribution in order to secure a public goods bonus. In the main experimental treatment, half of the participants received deceptive information that their group was not able to secure the public good, because there were not enough contributions. After this feedback (good or bad), they were given the option to select whether they want a leader or not. In two experimental studies participants were more likely to select a leader after they were unable to obtain the public goods resource. This means that subjects were conditionally less resistant toward hierarchy when the group has failed. In a similar study, Rutte and Wilke (1984) introduced a modified public goods game where the group was given a fixed resource (a common pool) and each

member was given an option to extract resources from it. After the extraction, the public pool was replenished at a fixed rate. The main experimental treatment was whether participants received information that their group used optimally, underused, or overused the resource. This was manipulated by giving information about the replenishment rate to participants, which was either mean, high, or low replenishment rate. The overuse situations represent a significant failure in the collective action problem. In such situations, subjects were more likely to prefer a leader who was able to harvest in the name of the group. The expectations and procedures were based on previous researcher by Messick et al. (1983), and replicated their findings. Similar results as De Cremer and Van Vugt (1999) and Rutte and Wilke (1984) were replicated cross-culturally (Samuelson, Messick, Rutte, & Wilke, 1984). Also, they fall in line with studies showing that participants are more likely to endorse leaders if the group is successful with a leader in a given task (Hollander & Julian, 1970; Michener & Lawler, 1975).

Further to these results, a well-established finding from the field of political science is the so called "rally-round-the-flag effect" (J. R. Lee, 1977; Chapman & Reiter, 2004), which can be viewed as a generalization of some of the presented experimental studies. It represents a situation where there is a sudden increase in public approval for leaders/governments currently in charge, as a function of a dramatic external or internal event (war, sudden attack, etc). This effect has been studied predominantly in the context of American politics, and more specifically to explain presidential approval ratings. One example relates to the September 11 attacks, which led to severe casualties in the United States. The approval ratings of the incumbent president of the United States, George W. Bush, increased by 39% (from 51% to 90%) (Hetherington & Nelson, 2003). Throughout US history similar effects have been observed for multiple events and multiple presidents. For example, J. R. Lee (1977) found that, out of 52 major events for Roosevelt and Ford, almost all led to surges of approval for the president for different periods (between 1 and 3

months), which were above the typical monthly fluctuations. Some events include the outbreaks of wars (e.g. involvement in the Korean war), important international conflicts (e.g. the Cuban missile crisis), and important peace agreements (e.g. the end of the Vietnam war). From a subsequent analysis he showed that wars and military crises (i.e. "us vs. them" problems) were the most important events, in terms of temporal effects, leading to 5-months approval surges on average. Political leaders seem to be implicitly or explicitly aware of this phenomenon and to engage in aggressive foreign policies, especially in times of sub-optimal internal circumstances (Richards, Morgan, Wilson, Schwebach, & Young, 1993). This political strategy is one of the important tennets of governance (Q. Wright, 1965) and has been supported by empirical research (T. C. Morgan & Bickers, 1992). This suggests that approval may increase and resistance may decrease during collective action problems, and especially during the "us vs. them" variety.

To sum up, the hypothesis that individuals will be less resistant toward hierarchy during "us vs. them" collective action problems (in comparison to "us vs. nature" problems) has not been studied directly in experimental games from the field of behavioural game theory. The only indirect evidence for a conditional switch in preferences toward hierarchy comes from experiments which show that when the group is about to fail in solving a collective action problem, its members may prefer to have a leader with more power. More conclusive findings come from the field of political science, where an important result is the so called "rally-round-the-flag effect", which suggests that individuals are more supportive toward the leader of their nation when there is an external threat, such as a military crisis.

General methods The experiments in this chapter used the two-group contest game as a main paradigm, as in Study 1 and Study 2. In the baseline version, participants were divided into groups of several individuals and each group was randomly matched with another group to play for a prize. Group members were

asked to make a contribution decision, which is a proxy measurement of their effort. The sum of these contribution decisions is the total contribution of the group. The group with a higher total contribution received a higher probability to win the contest prize. In formal terms, the total contribution (X_i) was the sum of all individual contributions:

$$X_i = \sum_{i=1}^{N} x_i \tag{3.1}$$

where N is the number of players in the group and x_i is the contribution of player i.

In each contest, each group was paired against another group. In each pair, the probability of contest win for the focal group (P_i) was defined as:

$$P_i = \frac{X_i}{X_i + X_j}, \tag{3.2}$$

where X_j is the total contribution of the opponent of the focal group, calculated with the same equation as X_i.

In both Study 3 and Study 4 participants played in hierarchical groups with high- and low-power players (e.g. high- and low-rank players). Hierarchy in this case was defined in a political way, based on the power of one individual to influence the decisions of another individual. Thus, high-power individuals had influence over the decisions of the low-power individuals. Participants had to contribute to increase the probability of their group to win the prize in the contest. Moreover, they were asked whether they want to pay a number of points to resist the power imposed on them, which is a proxy measurement of their resistance preferences. Furthermore, I measured the net benefits of players, which can be defined as the leftover from their pots after their decisions, combined with the earnings from the contest, if it is won.

This definition of hierarchy can be indeed observed in real-world situations. For example, during war high-rank individuals (officers) may give direct orders to their

subordinates. Such orders may "force" the subordinates to participate in a risky maneuver, thus enforcing a contribution in terms of effort and high risk for the individual. Another alternative example, which is simulated well by the operational definition of hierarchy used in this chapter, is the procedure of taxation. In modern society, governments (e.g. the political leadership) extract resources from all low-rank individuals in the form of taxes. Furthermore, they use these resources for concrete policies and political actions, which may not be in unison with the citizens' preferences. In some cases, when the mismatch between citizens and government is too big, or when the taxation is too heavy, the low-rank individuals exert effort to reduce the power of the government over them by protesting against the taxation system or by systematically trying to avoid it (and thus risking prosecution). In other words, they effectively resist the power of the government over them.

Secondary goals Across all studies I will explore the effects of gender and time constraint on the contribution preferences of players. In terms of gender, the most interesting hypothesis is the so called "male warrior hypothesis", which suggests that mainly male players will put forth effort during "us vs. them" problems in comparison to "us vs. nature" problems (Vugt et al., 2007; McDonald et al., 2012). In terms of time constraint, previous research suggests that more intuitive decisions, e.g. decisions made under time pressure (Rand, 2016), will lead to higher degrees of effort or contribution (Bear & Rand, 2016; Rand, 2016).

Definition of political hierarchy As explained, in this chapter I have selected a concrete definition of political hierarchy, based on one player's ability to influence the decision of another player. In this definition, high-rank players have more influence than low-rank players. There are alternative ways to define political hierarchy. For example, often in the literature political rank has been defined based on the ability of one player to act first in a sequential public goods game,

as discussed in Section 1.4.1. In these experiments, the high-rank players are the ones that act first, and thus giving example, or leading, the rest of the group (see Kumru and Vesterlund (2010) for an example). These experiments, however, have a critical problem — namely the decision of the player is no longer anonymous, which may trigger basic social instincts, such as a willingness to look good in front of the group or social shame. Another possible definition of political hierarchy may be to allow high-rank individuals to distribute the earnings after the winning of the contest prize. However, this definition may conflate economic hierarchy and political hierarchy, as the high-rank player may be willing to give more to himself, rather than to all other players, thus triggering cognitive biases, such as inequality aversion (Blake et al., 2015; C. T. Dawes et al., 2007) or fairness considerations (Fehr & Schmidt, 1999, 2000, 2010). The most important issue with the definition of political hierarchy, used in this chapter, is that it is novel, e.g. it has never been applied in other experiments prior to this one. However, there are at least four reasons why I think this definition is appropriate for the research questions of this thesis. First, due to the anonymous nature of the players it does not trigger social biases, such as shame. Second, the difference between the high- and the low-rank player are not defined in economic terms, therefore rational considerations are not involved into the decision-making process. Third, it is centered around the concept of power, which may be seen as the building block of all political hierarchies (French et al., 1959; Dahl, 1957; Forsyth, 2009), therefore it is grounded in realistic assumptions. Fourth, it allows to study the aforementioned concept of resistance, which can be operationalized as the willingness of a low-rank individual to loss resources in order to reduce the power of the high-rank individual or the group. Therefore, despite the fact that the definition is novel, it seems like a good candidate to both minimize the potential confounding factors, stemming from alternative definitions, and to highlight novel behaviours.

Overview of results Based on the research hypotheses listed above, results from the experiments in this chapter suggest again a rather mixed picture, which differs both from previous empirical research and from the studies presented in Chapter 2. Under political hierarchy, high-power participants did not exert more effort and did not earn less than low-power participants. However, contrary to groups with economic hierarchy, the introduction of power-based in-group difference increases the performance of hierarchical groups in comparison to egalitarian groups. The collective action problem type, the gender of players, and the decision-making speed did not affect the contribution and resistance preferences of players in an unconditional manner

3.2 Study 3

The goal of Study 3 was to put an emphasis on two of the proposed questions in this thesis. Namely, I asked whether the type of collective action problem faced by the group influences the contribution and resistance preferences of players. I predicted that "us vs. them" problems will lead to more contribution (**H4**) and less resistance (**H5**) in comparison to "us vs. nature" problems or less severe "us vs. them" problems.

The study had two experiments, Experiment 3a and Experiment 3b, which were executed online. The sample for Experiment 3a consisted of 350 participants, while the sample for Experiment 3b consisted of 347 US participants.

General methods for both experiments are presented in Appendix C.1, while the analytical framework used in all experiments is presented in Appendix C.2.

3.2.1 Experiment 3a

Methods

Participants were recruited through Amazon's Mechanical Turk. I recruited only US participants and verified their location through their IP addresses. The experiment was executed online through the survey platform Qualtrics. The experiment had a 2x2 experimental design, described below, which can be seen in Figure 3.1.

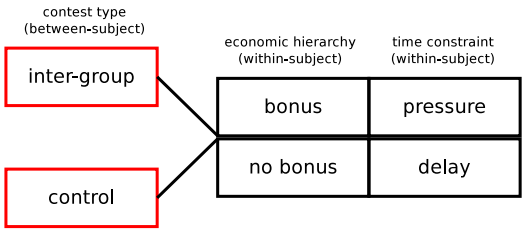


Figure 3.1: Graphical representation of the experimental design of Experiment 3a. Contest type was a between-subject variable with two treatments. Therefore, participants were split randomly to play one of the two contest types at the beginning of the experiment. Economic system type and time constraint were within-subject variables with four treatment combinations in total.

Participants were randomly allocated to groups of three to play four rounds of a contest game, where their group success and earnings depended on their total group contribution. In each round, the prize was 600 points. Participants were told that they will be divided into two player types: high-power players and low-power players. In each group, there was one high-power player and two low-power players. Participants were told that the high-power player in each group was asked how much they want all other players to contribute to the group's success. This decision is called their power use preference. However, this information constituted a deception, as no player was actually assigned to the high-power role. In fact, all players were assigned to a low-power position. Therefore, I was unable to test the first research hypothesis in this chapter, namely that high-power individuals will contribute more than low-power individuals.

The low-power players were asked (i) how much they want to contribute to

the group's success in the contest (their contribution preference) and (ii) how much they are prepared to "pay" in order to resist the power use preference of the high-power player (their resistance preference).

Each low-power player was given two endowments to make decisions with: an endowment of 100 points (the contribution pot) for the decision to contribute or not to the group's success, and an endowment of 100 points (the resistance pot) for the decision to reduce (or not) the power of the high-power player.

Participants were told that the final contribution decision (henceforth, adjusted contribution) of each low-power player depended on their contribution and resistance preferences and on the power user preference of the high-power player in their group. They were not given the exact dependencies between these variables but were given the following instruction:

> Imagine a situation where you prefer to contribute 50 points from your contribution pot, whereas the high-power player in your group decides that you contribute 100 points:
>
> - If you use 100 points from your resistance pot, you will control 100% of your decision. In this scenario, you will contribute your preferred amount of 50 points;
> - If you use 50 points from your resistance pot, you will control 50% of your decision, and the other 50% will be controlled by the high-power player. In this scenario, you will actually contribute 75 points;
> - If you use 0 points from your resistance pot, you will control 0% of your decision. In this scenario, you will actually contribute 100 points.

This example is based on the following formal definition of the dependencies between the three preferences:

$$x_i^{adj} = x_i \frac{r_i}{r_{max}} + \pi_i (1 - \frac{r_i}{r_{max}}) \tag{3.3}$$

where x_i^{adj} is the adjusted contribution, x_i is the contribution preference, and r_i is the resistance preference of the focal player, while r_{max} is the maximum

possible resistance (e.g. 100 points) and π_i is the power use preference of the high power player in the group of the focal low-power player. As explained in the example, this expression allows the focal low-power player to decide how much influence the high-power player will have over his/her adjusted contribution decision. A visual representation of the power dynamic model used in Experiment 3a can be seen in Figure 3.2.

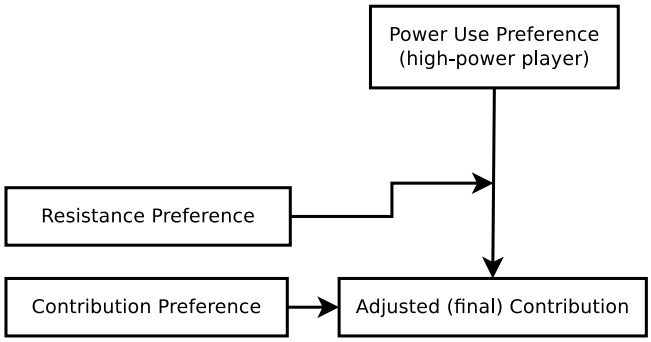


Figure 3.2: Graphical representation of the power dynamic of Study 3a. The adjusted contribution of the low-power players depends on their contribution and resistance preferences and on the power use preference of the high-power player. In the representation, all arrow lines indicate influence of one variable over another. If an arrow line is pointing toward another arrow line, this indicates mediation.

Contest type Before the beginning of the experiment, participants were split randomly to play one of two contest types. In the *inter-group contest* condition, the probability of each group winning the prize depended on the number of points contributed by the low-power players in the group, relative to the number of points contributed by the low-power players in the opponent group. In the control contests condition, the probability of winning the prize depended on the number of points contributed by the low-power players in the group, relative to the number of points contributed by the experimental software. This variable was defined in the same way as in Study 1 and Study 2. It can be interpreted as a minimal groups manipulation which emphasizes the salience of the other group, as in the inter-group contests case groups were divided based on chance (e.g. participants were assigned to groups at random).

Economic system type In half of the rounds participants played in *hierarchical economic system*, where they were told that the high-power player in their group will earn 400 points if the group wins the prize, while all low-power players will earn only 200 points. In the other half, participants played in *egalitarian economic system*, where they were told that all players in the group, including the low-power players, will earn 200 points if they win the prize.

The goal of this manipulation was to test the degree of resistance toward economic hierarchy based on income (as in Study 1 and Study 2). Furthermore, it allowed me to assess whether the contribution preferences of players increase or decrease when an economic hierarchy is introduced.

Time constraint In half of the rounds players played under *time pressure* and were asked to make their decisions in under 10 seconds. They were shown a visual countdown on their screens. In the remaining rounds they were asked to play under *time delay* and had to wait for 15 seconds before they could make their decisions.

Full materials for Experiment 3a are presented in Appendix C.3.

Participants and power analysis For Experiment 3a I recruited 400 US participants. Of these participants, 50 were removed as they were unable to answer at least two of the comprehension questions in the quiz correctly. Thus, the final sample for Experiment 3a consisted of 350 participants (Female = 164, Male = 186), with a mean age of 39.8 years, ranging from 18 to 77 years (SD = 12.8).

The sample size was determined based on financial and logistics constraints. A power analysis indicates that the design has a power of $\beta \geq 0.8$ at $\alpha = 0.05$ for an effect size of ≥ 0.27 for the contest type variable and ≥ 0.19 for the economic system type and time constraint variables.

Results and discussion

I executed LME models for all dependent variables of interests. Full results from the models and estimated marginal means (EMM) comparisons can be seen in Appendix C.4. Decisions that did not comply to the time constraint during time pressure manipulations were removed. The number of removed decisions for the contribution variable were 14 or 1% of all decisions. The number of removed decisions for the resistance variable were 23 or 1.64% of all decisions. The removed decisions were not imputed.

In terms of contributions, the LME model revealed that all variables were involved only in a significant 4-way interaction, F(1, 343.74) = 12.28, $p < 0.001$, R^2_{sp} = 0.003. The only statistically significant contrast effect was when male participants played inter-group contests under time pressure, t(673.15) = 2.36, $p < 0.019$, d = 0.38. In this case, male participants contributed more in egalitarian economic systems (EMM = 73.16, SE = 2.83) than in hierarchical ones (EMM = 66.86, SE = 3.01). Thus, the hypothesis (**H4**) that participants will contribute more during inter-group contests than during control contests was not supported by the data. In other words, the salience of the out-group was not influential.

In terms of resistance, the LME model revealed no main effects or interactions associated with the independent variables. Therefore, **H5** was not supported by the data.

An exploratory EMM comparison revealed that under time pressure, low-power participants were more resistant toward the high-power player when s/he earns more (EMM = 36.81, SE = 1.92) than when s/he earns as much as they do (EMM = 33.15, SE = 1.89), t(661.96) = -2.11, $p < 0.035$, d =-0.185. Therefore, economic hierarchy introduced more resistance only when participants were making their decisions under time pressure. In all other cases, the difference was not statistically significant. The effect suggests that people's intuition may be not only to resist

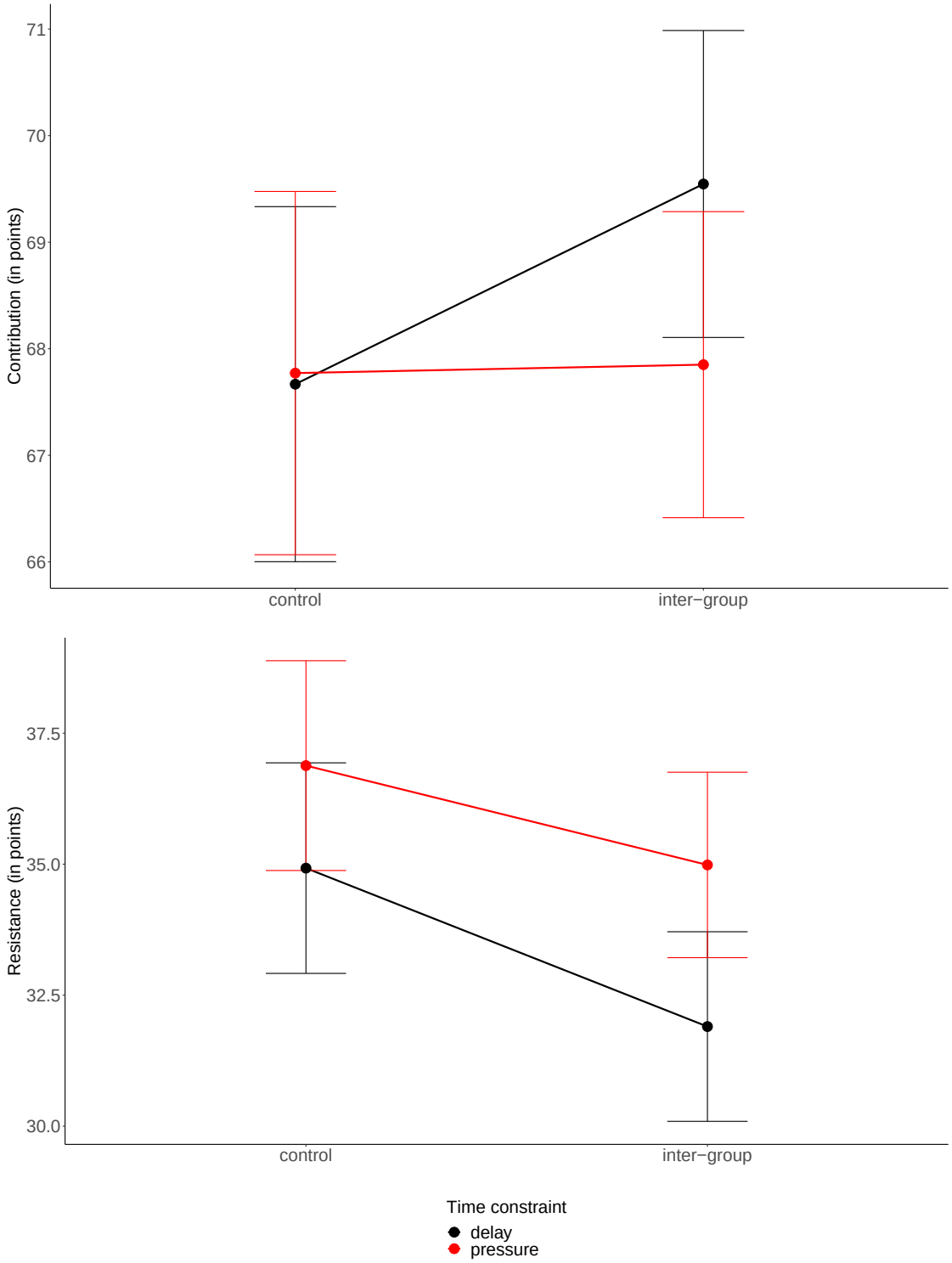


Figure 3.3: Experiment 3a: Contribution and resistance by economic system type and time constriant. In terms of contribution, all independent variables were invoved in an interaction. Error bars represent one standard error.

economic hierarchy but also resist the power of players who earn more.

In summary, despite the conditional results, neither **H4** nor **H5** were supported by data, as neither the resistance nor the contribution preferences of players were affected by the contest type variable.

3.2.2 Experiment 3b

The goal of Experiment 3b was to test a modified version of the two hypotheses explored in Experiment 3a (**H4** and **H5**). Namely, instead of modifying the type of collective action problem from "us vs. them" to "us vs. nature", I modified the difficulty of the "us vs. them" collective action problem from less difficult to more difficult (see Methods section for further details).

Methods

Participants were again recruited through Amazon's Mechanical Turk. All participants were from the United States. The experimental interface was developed in oTree (D. L. Chen, Schonger, & Wickens, 2016), a framework for interactive online experiments, based on the Python programming language. The general setup closely resembled the one in Experiment 3a. Six participants played the game synchronously in the online platform, thus they played the game at the same time and received feedback about their and their group's performance in each round. Measures to minimize inattention are explained in Appendix C.1.

Participants were invited to the experimental platform in batches of six players. They were split into two groups of three players and played four rounds of a contest game. Furthermore, they were told that players in each group would be divided randomly into one high-power and two low-power players. Contrary to Experiment 3a, this was not a deception, as one third of all participants were assigned to a high-power role. The experiment had a 2x2 experimental design,

described below, which can be seen in Figure 3.4.

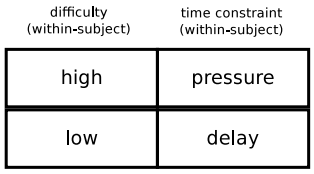


Figure 3.4: Graphical representation of the experimental design of Experiment 3b. Inter-group contest difficulty and time constraint were within-subject variables with four treatment combinations in total.

In each round, high-power players were asked to make a decision about their power use preference, e.g. about the preferred amount of points they wish the low-power players in their group to contribute. Low-power players, on the other hand, were asked about their contribution and resistance preferences. They were given contribution and resistance pots of 100 points each for their decisions in each round. The experiment included 112 high-power players and 237 low-power players.

As in Experiment 3a, the adjusted contribution decision of each low-power player depended on their contribution and resistance preferences and on the power use preference of the high-power player. The higher the resistance preference of the focal low-power player, the higher their influence over their decision in comparison to the influence of the high-power player. Therefore, the power dynamic in the experiment followed the same formal definition as the one described in eq. (3.3).

Inter-group contest difficulty Half the rounds involved inter-group contests with *low difficulty*, while the other half involved inter-group contests with high difficulty. In the *low difficulty* condition low-power players were given a bonus of 40% to their adjusted contribution decision. For example, if a low-power player's adjusted contribution decision (x_i^{adj}) was 50 points, s/he received a bonus of 20 points. Thus, her/his actual contribution was 70 points, despite the fact that only 50 points were removed from her/his contribution pot. Thus, the contributions of players in this condition "bought" them more probability to win the prize in the

contest. In *high difficulty* conditions low-power players received a 40% reduction of their adjusted contribution decisions (x_i^{adj}). For example, if a low-power player decided to contribute 50 points toward the group's success, s/he received a reduction of 20 points. Thus, her/his actual contribution was 30 points, despite the fact that 50 points were removed from her/his contribution pot. In other words, the collective action problem for such groups was more difficult, in comparison to the cases with low difficulty, as winning the contest required more contribution.

In each group, all players were assigned either to a low- or to a high-difficulty condition. This manipulation has been used in previous experiments in behavioural game theory (Bhattacharya, 2016) and has been modeled as the collaborative effort (or efficiency) of the group in theoretical models (Gavrilets, 2014).

In real world situations, this abstracted manipulation simulates cases where the strength of the competing groups is asymmetric. For example, during war, larger groups, with stronger individuals in their ranks, may have higher probability to win, in comparison to smaller groups, with weaker individuals. In such cases, the smaller groups may have to exert more effort than the larger groups in order to secure a successful outcome in the collective action problem at hand.

Time constraint As in Experiment 3a, in half of the rounds participants had to play under *time pressure* of 10 seconds, while in the other half they had to play under *time delay* of 15 seconds.

Full materials can be seen in Appendix C.5.

Participants and power analysis The sample for Experiment 3b consisted of 347 US participants (Female = 150, Male = 197), with a mean age of 35.44 years, ranging from 20 to 71 years (SD = 10.03). One participant was removed from the descriptive statistics of age as s/he has provide an age of 6. The data of this participant was not removed from the analyses, as it did not show any

signs of abnormality.

The sample size was determined based on financial and logistics constraints. A power analysis indicates that the design has a power of $\beta \geq 0.8$ at $\alpha = 0.05$ for an effect size of ≥ 0.19 for all variables.

Contrary to Experiment 3a, in this study I did not use a quiz to sift comprehenders from non-comprehenders. The rationale stemmed from the synchronous nature of this experiment. By design, each round began when all participants were ready with their decisions. Thus, if one participant was inattentive during the experimental procedure, all other participants had to wait for her/his decision. In other words, the pace of the experiment depended on the slowest participant. I decided to remove the quiz in this experiment as it slowed down the experimental procedure significantly, therefore it increased the attrition rate.

Results and discussion

I executed LME models for all dependent variables of interests. Full results from the models and estimated marginal means (EMM) comparisons can be seen in Appendix C.6. Decisions that did not comply to the time constraint during time pressure manipulations were removed. The number of removed decisions for the contribution variable was 22 or 2.32% of all decisions. The number of removed decisions for the resistance variable was also 22 or 2.32% of all decisions. The removed decisions were not imputed.

In terms of contributions preferences for low-power players, the LME model did not produce any statistically significant main effects or interactions. Therefore, the modified version of **H4** was not supported by the data, as the inter-group contest difficulty variable was not influential.

In terms of resistance preference, the LME model revealed that the inter-group contest difficulty variable was not influential, therefore the modified version of **H5** was also not supported by the data.

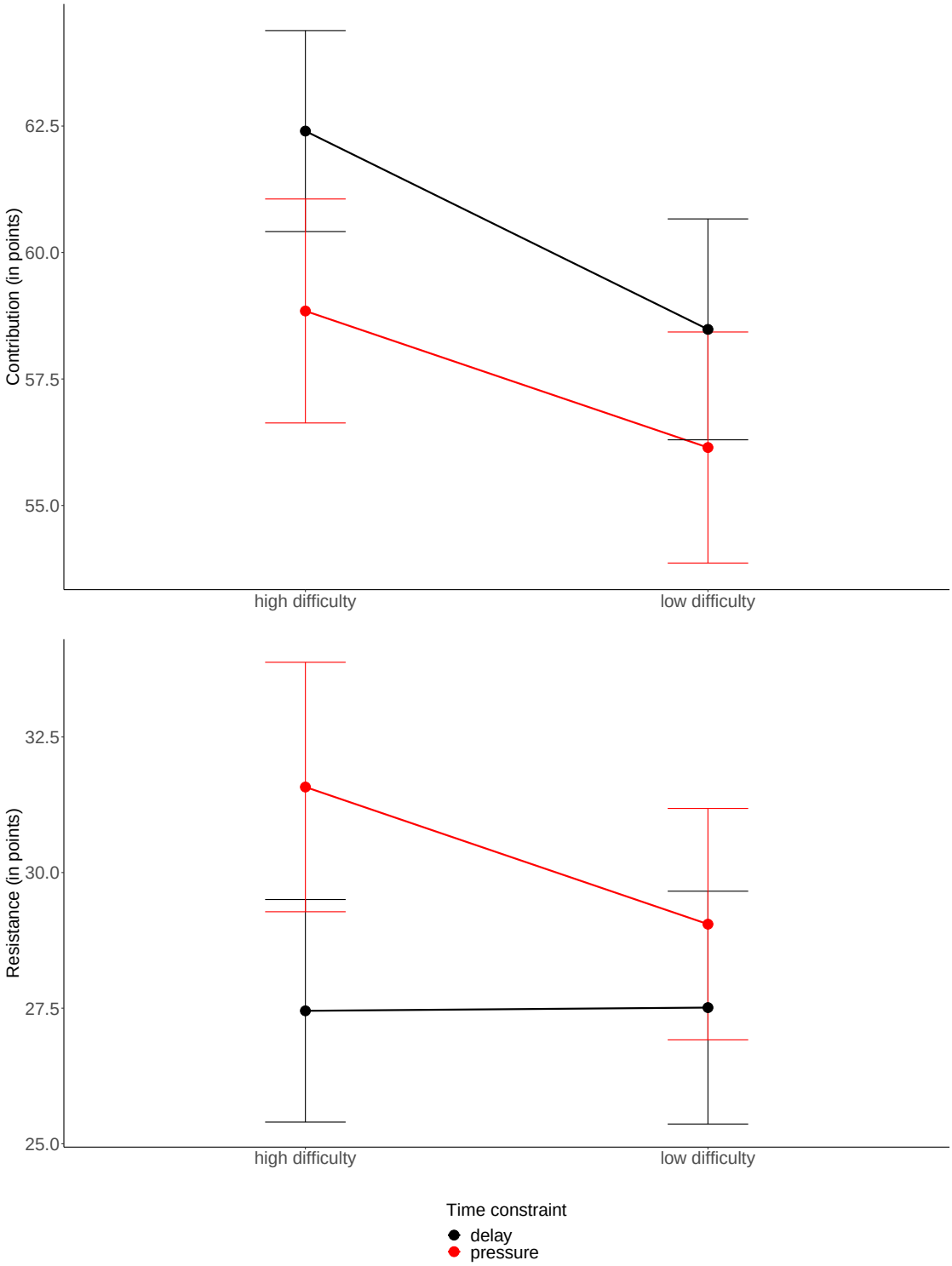


Figure 3.5: Experiment 3b: Contribution and resistance by inter-group contest difficulty and time constraint. The independent variables do not influence directly any of the dependent variables. Error bars represent one standard error.

In terms of resistance, only the gender variable yielded a statistically significant main effect, F(1, 235.05) = 3.97, $p < 0.047$, $R^2_{sp} = 0.01$. Female participants used 32.37 points from their resistance pots ($SD = 33.38$) while male participants used 26.07 points ($SD = 32.12$). However, the variable was involved in a significant 3-way interaction with time constraint and inter-group contest difficulty, F(1, 233.34) = 11.87, $p < 0.001$, $R^2_{sp} = 0.007$. An EMM comparison further revealed that the difference between male and female participants was significant only under time pressure and during inter-group contests of higher difficulty, t(299.84) = 3.81, $p < 0.001$, $d = 0.71$. In such cases, female participants resisted the high-power players more ($EMM = 41.22$, $SE = 3.29$) than male participants ($EMM = 24.49$, $SE = 2.91$).

In sum, the main hypotheses of this study were not supported by data, as neither resistance, nor contribution were affected by the fact that the inter-group contest type was of higher or lower difficulty.

3.3 Study 4

Study 1 and Study 2 tested only questions regarding contribution preferences, while the main focus of Study 3 was the resistance and contribution preferences changes of low-power players in hierarchical groups during various forms of collective action problems.

In Study 4, I tested all research questions from the previous studies at once by using a novel political definition of hierarchy. The introduction of this definition of hierarchy further allowed me to unstack the odds against the altruistic bully hypothesis. In Study 1 and Study 2, hierarchy was based on economic income, thus high-rank players actually earned more than the low-rank players by default, making it less likely for them to receive a smaller net benefit. Political hierarchy, as defined in this study, allowed me to mitigate the issue, as the differences between high- and low-rank players were based only on power (and not economic means), thus the two

player types were expected to earn the same amount of monetary units from the contest prize. Furthermore, with this definition of hierarchy, I was able to study the contribution and resistance preferences of both the high- and the low-power individuals in the group, which was not done in Study 3, as there the focus was on the preferences of the low-power players. An interesting component of Study 4 was that I used samples from social groups with real antagonism. Namely, in Experiment 4a I recruited UK Christian participants which were led to believe that they will play the contest game against groups of UK Muslim participants. In Experiment 4b I recruited ethnic Bulgarian participants which were led to believe that they will play the game against a group of ethnic Roma participants. This allowed me to test the effect of "us vs. them" problems on group performance both with real-world groups and with antagonisms of different type (e.g. religions and ethnic).

The sample for Experiment 4a consisted of 382 UK Christian participants, while for Experiment 4b the final sample consisted of 266 ethnic Bulgarian participants.

General methods for both experiments are presented in Appendix D.1, while the analytical framework used in all experiments is presented in Appendix D.3. As both experiments were executed without feedback, I developed a Monte Carlo simulation, similar to the one in Study 2. The simulation uses all decisions of players to produce a distribution of possible outcomes for each decision. Extended rationale and explanations of the simulation are presented in Appendix D.2.

3.3.1 Experiment 4a

Methods

Participants were recruited through the Prolific Academic service (Palan & Schitter, 2018). All participants played the experimental game through the survey platform Qualtrics. In Prolific Academic, participants were selected to be from the United Kingdom and to have been self-categorized as Christians. They were

told that in some cases they will play the contest game against a group of UK Muslim participants.

Anti-Muslim prejudices Indeed, anti-Muslim prejudices have been observed extensively in the UK. Media coverage often revolves around the ideas of extremism, military threat, threat to democracy, and threat to gender equality (Richardson, 2004). Tolerance toward Muslims in the UK is usually seen as a function of religiosity, as more religious UK citizens are more likely to be prejudiced (Fetzer & Soper, 2003). After the events of September 11, anti-Muslim prejudice skyrocketed, expressed mainly through racism, xenophobia, and acts of physical violence and aggression (C. Allen & Nielsen, 2002; Sheridan & Gillett, 2005). Furthermore, even before the events of September 11, research employing data from the 1999–2000 wave of European Values Study found that within Europe the level of anti-Muslim prejudice was high and could not be explained mainly by anti-immigrant prejudice. Indeed, in the United Kingdom, 13.89% of the population did not want to have a Muslim as a neighbor, which was the main technique to measure the degree of prejudice. Therefore, the contest type manipulation (UK Christian vs. UK Muslim) has basis in the real-world dynamic between the two groups.

The experiment had a 2x2x2 design, described below, which can be seen in Figure 3.6.

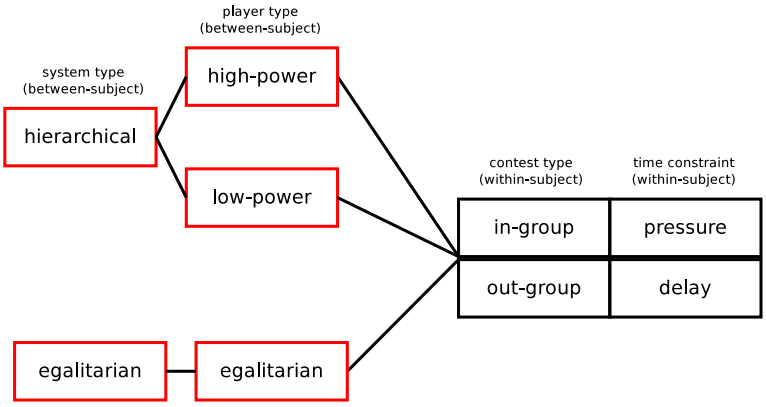


Figure 3.6: Graphical representation of the experimental design of Experiment 4a. Political system type and player type were between-subject variables with two treatments each. Therefore, participants were split randomly to play in one of the two political system types and in one of the two ranks at the beginning of the experiment. Time constraint was a within-subject variable with two levels.

In the experiment, participants were told that they will be randomly allocated to groups of four players and that they would play four rounds of a contest game. In each round of the game, each participant was assigned two endowments to make decisions with: (i) an endowment of 100 points (the contribution pot) and (ii) another endowment of 100 points (the resistance pot), to make their contribution and resistance decisions respectively. Furthermore, to measure the power use preference of each player, they were asked "How many points do you wish each group member to contribute?". Participants in each group of four players were asked to reach a group decision. The group decision was based on the power use preference of each individual in the group.

The adjusted contribution decision of each player depended on (i) his/her contribution preference (ii) the contribution assigned to her/him by the group, and (iii) the payment s/he has made to resist the power of the group. The instruction was similar to the one given in Experiment 3a (Section 3.2.1).

In formal terms, this dependency can be explained with the following function:

$$x_i^{adj} = x_i \frac{r_i}{r_{max}} + \Pi_i (1 - \frac{r_i}{r_{max}}) \tag{3.4}$$

where x_i^{adj} is the adjusted contribution, x_i is the contribution preference, r_i is the resistance preference, and r_{max} is the maximum possible resistance (e.g. 100 points) of the focal player, while Π_i is the group decision of the focal player's group. Thus, the adjusted contribution was calculated based on the focal player's preferences for contribution and resistance, and on the group decision.

A visual representation of the power dynamic model used in Experiment 4a can be seen in Figure 3.7.

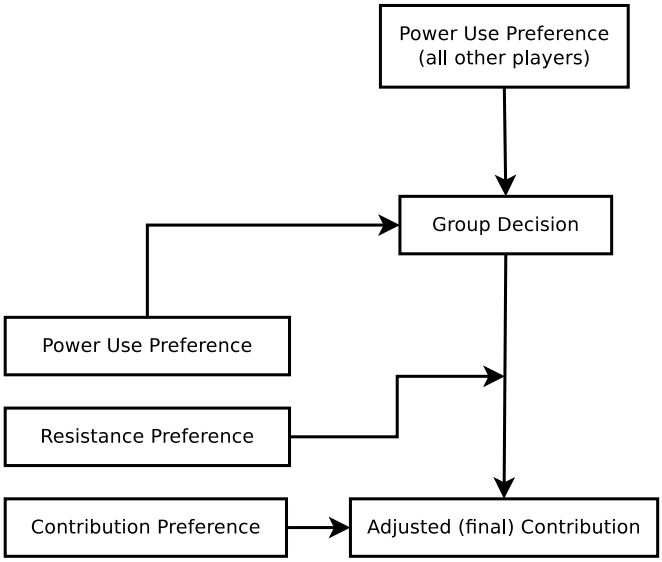


Figure 3.7: Graphical representation of the power dynamic of Study 4. The adjusted contribution depends on the contribution and resistance preferences of the player and the group decision. The group decision depends on the power use preference of all players in the group. In the representation, all arrow lines indicate influence of one variable over another. If an arrow line is pointing toward another arrow line, this indicates mediation.

As the study was executed without feedback, the adjusted contributions of players were estimated with a Monte Carlo simulation, the details of which can be seen in Appendix D.2.

System type The group decision depended on the system type variable. Before the beginning of the study, participants were assigned randomly to play either in an egalitarian or in a hierarchical political system. In groups with an *egalitarian system*, the group decision was the average over all power use decisions. Thus, in egalitarian

groups there were no individuals of higher power, as all players influenced the contribution rate of all other players equally. To illustrate the situation, imagine a case where two of the players decide that each player in the group should contribute 100 points, while the remaining two players decide that each player in the group should contribute 0 points. The value of the group decision in that case is 50 points, which is the mean between these four decisions. In groups with a *hierarchical system* the group decision was the weighted average over all power use decisions. In such groups, participants were randomly divided into two player types: high-power players and low-power players. The high-power players had 40% influence over the group decision, while the low-power players had only 10% influence over the group decision. Thus, in hierarchical groups, some individuals were able to influence all other players more than other individuals were.

In formal terms, in egalitarian groups, the group decision (Π_i) was the mean of all individual power use decisions, or:

$$\Pi_i = \frac{\sum_{i=1}^{N} \pi_i}{N} \tag{3.5}$$

where π_i is the power use decision of each player and N is the number of players in the group.

In hierarchical groups, the group decision was the weighted mean of all individual power use decisions, or:

$$\Pi_i = \sum_{i=1}^{N} \pi_i \times \omega_i \tag{3.6}$$

where w_i is the weight of each player's power use decision over the group decision. In hierarchical groups, high-power players received a weight of their power use decision of 40% (e.g. $\omega_i = 0.4$), while low-power players received a weight of their power use decisions of 10% (e.g. $\omega_i = 0.1$).

A similar operational definition of hierarchy, as a weighted sum of all individual preferences within a contest situation, has been used by theoretical models (Makowsky & Smaldino, 2016).

Player type In most of the statistical models, the system type variable was reformulated as *player type* or rank, which has three levels: *high-power players* in hierarchical groups, **low-power players** in hierarchical groups, and *players in egalitarian groups*.

Contest type In half of the rounds, all UK Christian participants currently in the game played *in-group contests* against a group of other UK Christian participants. In the other half, they were told that they would play *out-group contests* against a group of UK Muslim participants. In fact, this constitutes a deception, as in all cases there was no such group. As participants were playing the contest game without feedback, they were only led to believe that they were playing the game with a real group.

Time constraint As in Experiment 3a and Experiment 3b, in Experiment 4a participants had to play half of the rounds with a *time pressure* of 10 seconds and the other half with a *time delay* of 15 seconds.

Out-group attitudes To do a manipulation check regarding the attitude of the UK Christian participants toward the UK Muslim group, I asked them the following question: "What is your general attitude regarding the UK Muslim group?". Participants were able to answer the question on a 7-item Likert scale, where 1 = very negative and 7 = very positive. This is a standard question, used previously in the experimental literature (see Weisel and Böhm (2015) for example). To use this variable in the models, I transformed it by categorizing participants into two categories: "negative" and "neutral/positive". Participants who answered with either "very negative", "negative", or "slightly negative" were categorized into the

"negative" category. Participants who answered with "neutral", "slightly positive", "positive" or "very positive" were categorized into the "neutral/positive" category. This new variable will be called "out-group attitudes" henceforth and was used as an independent variable in all models. The number of players assigned to the "positive/neutral" level was 274, while the number of players assigned to the "negative" level was 108. This allowed me to see whether the attitudes of the participants interact with their preferences, the degree of hierarchy, and the collective action problem type.

Full materials are presented in Appendix D.4.

Participants and power analysis For Experiment 4a I recruited 410 participants. Of these participants, 28 were removed as they were unable to answer at least two of the comprehension questions correctly. Thus, the final sample for Experiment 4a consisted of 382 participants (Female = 288, Male = 94), with a mean age of 40.1 years, ranging from 18 to 71 years (SD = 12.36).

The sample size for Experiment 4a was determined based on financial and logistics constraints. A power analysis indicates that the design has a power of $\beta \geq 0.8$ at $\alpha = 0.05$ for an effect size of ≥ 0.25 for the system type variable , ≥ 0.09 for the player type variable, and ≥ 0.18 for the contest type and time constraint variables.

Results and discussion

I executed LME models for all dependent variables of interests. Full results from the models and estimated marginal means (EMM) comparisons can be seen in Appendix D.5. Decisions that did not comply to the time constraint during time pressure manipulations were removed. The number of removed decisions for the contribution variable was 22 or 1.44% of all decisions. The number of removed decisions for the resistance variable was 35 or 2.29% of all decisions. The removed decisions were not imputed.

Results from the LME model of contributions indicated that the difference between high- and low-power players was not significant in terms of contributions under any circumstances, therefore **H1** was not supported by the data.

The LME model of expected net benefits indicated that high-power players earned less than low-power players, but that was conditional on the contest type being in-group. On average, high-power players earned 195.87 points (SD = 33.82), low-power players earned 203.25 points (SD = 36.83), while players in egalitarian groups earned 202.88 points (SD = 31.86), F(2, 370) = 3.49, $p < 0.032$, R^2_{sp} = 0.01. Based on an EMM contrast comparisons, the only significant difference was between high-power players in hierarchical groups and players in egalitarian groups, t(370) = 2.63, $p < 0.024$, d = 0.68. Furthermore, a second EMM comparison, which explored the differences of ranks as a function of contest type, revealed that high-power players earned less than low-power players as well, however this was conditional on the contest type being in-group, t(370) = -2.543, $p < 0.031$, d =-0.78. Therefore, these results suggest that the altruistic bully hypothesis (**H2**) was not supported by the data, as high-power players did not earn less than low-power players during out-group collective action problems.

Based on the LME model for the adjusted contribution preferences of players, hierarchical groups contributed more under certain circumstances than egalitarian groups. More specifically, while the model did not reveal a significant main effect of system type, the variable was involved in a significant 3-way interaction with contest type and time constraint, F(1, 374) = 6.99, $p < 0.009$, $R^2_{sp} = 0.002$.

Further EMM comparisons revealed that hierarchical groups outperformed egalitarian groups when players were making their decisions under time pressure during out-group contests, t(441.73) = -2.025, $p < 0.043$, d =-0.443. In such cases, the expected adjusted contribution in hierarchical groups was more points (EMM = 61.45, SE = 1.47) than in egalitarian groups (EMM = 57.31, SE = 1.42). Furthermore, the same effect was found when players were playing in-group

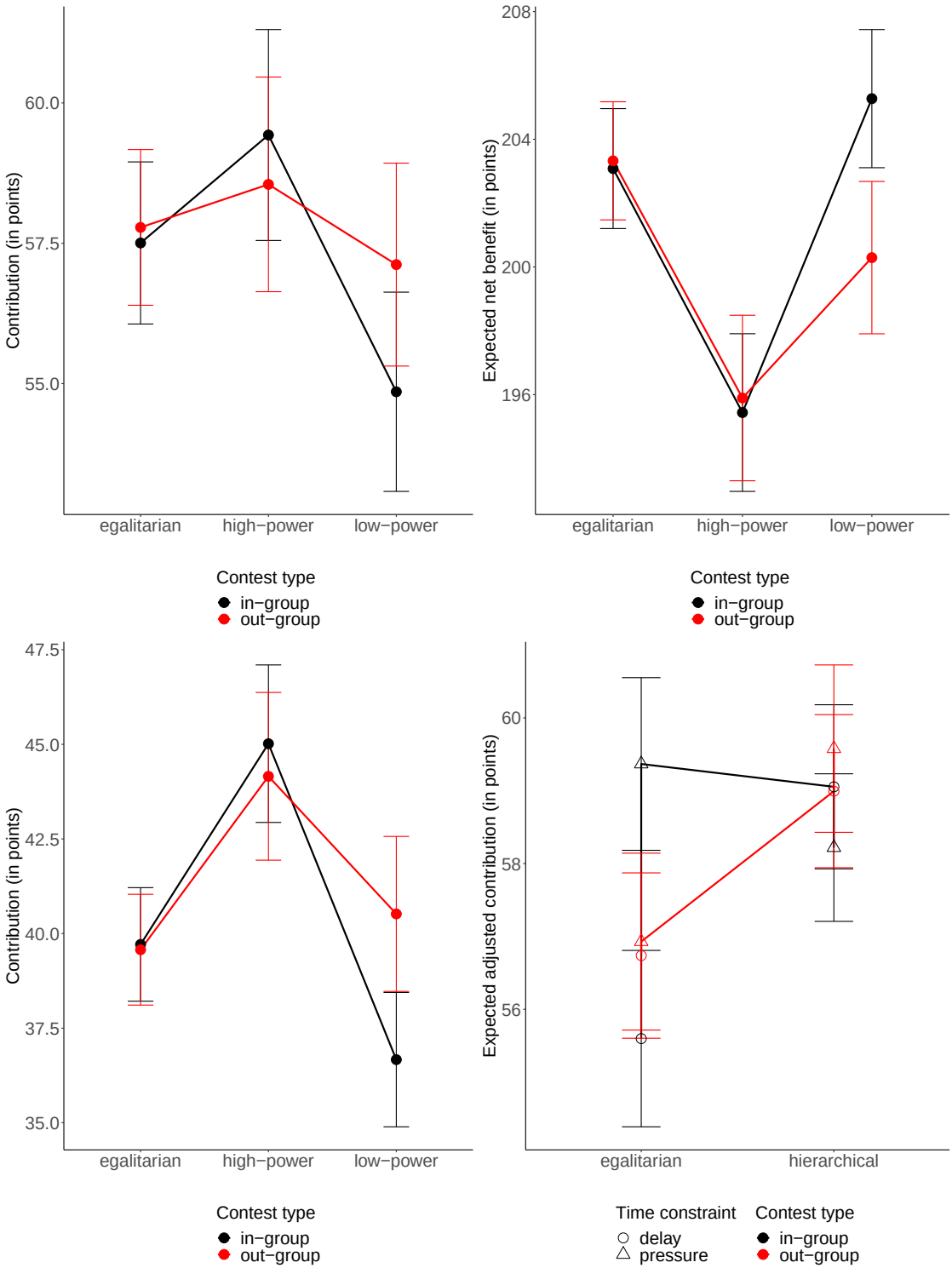


Figure 3.8: Experiment 4a: Contribution, expected net benefit, and resistance by player type and contest type; adjusted contribution by player type, contest type, and time constriant. Hierarchical groups outperformed egalitarian groups, conditional on the time constraint and contest type variables. Error bars represent one standard error.

contests with time delay, t(444.06) = -2.141, $p < 0.033$, d =-0.461. In such cases, the expected adjusted contribution in hierarchical groups was more points (*EMM* = 59.1, SE = 1.45) than in egalitarian groups (*EMM* = 54.8, SE = 1.39). Thus, **H3** was supported conditionally on the time constraint variable.

Unexpectedly, based on the LME models of contribution and resistance, the contest type (out-group vs. in-group) did not have a statistically significant influence, therefore both **H4** and **H5** were not supported by the data.

In this experiment, there were a set of exploratory findings. Based on the LME model for resistance, only the player type variable influenced the resistance preferences of players, F(2, 371.82) = 3.2, $p < 0.042$, $R^2_{sp} = 0.01$. High-power players used 44.59 points (*SD* = 28.28) from their resistance pot, low-power players used 38.59 points (*SD* = 26.41), while players in egalitarian groups used 39.64 points (*SD* = 29).

Statistically, egalitarian players used less points from their resistance pot (*EMM* = 39.28, SE = 2.11) than high-power players in hierarchical groups (*EMM* = 49.05, SE = 3.38), t(372.6) = -2.451, $p < 0.039$, d =-0.614. Thus, in terms of resistance preferences, high-power players were unexpectedly more resistant than players in egalitarian groups. Therefore, probably as a function of their resistance preferences, which correlate negatively with the expected net benefit variable, high-power individuals earned less than egalitarian players from the strategic situation, as previously discussed.

The LME model for contribution further revealed that the time constraint and gender variables were involved in a significant interaction with each other, F(1, 386.5) = 3.94, $p < 0.048$, $R^2_{sp} = 0.001$, and in a significant interaction with contest type and player type, F(2, 384.03) = 3.3, $p < 0.038$, $R^2_{sp} = 0.001$.

A set of EMM comparisons suggested that the main effect of time constraint in this dataset was driven by a specific subset of participants, namely by male high-power participants, playing out-group contests, t(797.73) = -2.582, $p < 0.010$,

d =-1.026. Such players contributed more points under time pressure (EMM = 72.06, SE = 7.16) than under time delay (EMM = 56.62, SE = 6.46). Therefore, a highly conditional result was that male high-power participants, playing out-group contests, were more likely to contribute under time constraint than under time delay.

In sum, in Experiment 4a only **H3** was partially supported by data, as hierarchical groups outperformed egalitarian groups in some circumstances. High-power individuals neither contributed more nor did they earn less than low-power individuals. The contest type also did not affect the contribution and resistance preferences of players in an unconditional way.

3.3.2 Experiment 4b

Methods

The experiment closely replicated closely the design and procedure of Experiment 4a. The only difference was that instead of ethnic UK Christian participants, I used a sample of ethnic Bulgarian participants. In some cases, the Bulgarian participants were told that they will play the contest game against a group of Roma participants (out-group contests), while in other cases they were told that they will play the game against a group of other Bulgarian participants (in-group contests). All materials from Experiment 4a were translated by myself, as I am a native speaker, and are presented in Bulgarian in Appendix D.6.

Ethnic Bulgarian vs. ethnic Roma Bulgaria is a multi-ethnic country, with population consisting of three major ethnic groups: ethnic Bulgarians, ethnic Roma (or Gypsies), and ethnic Muslims. The Muslims can be further divided into two sub-groups: Pomaks (Slavic Muslims) and Turks (Бюксеншютц & Георгиев, 2000). There are constant ethnic tensions between the main groups, which are rooted in the dominance relationships developed during the communist regime

(Пампоров & Желязкова, 2006). More specifically, in the capital of the country, Sofia, Roma people are segregated into ghettos and severely marginalized (Пампоров & Желязкова, 2006). This has led to high rates of "visible" crime and anti-social behaviour, and severe stereotyping of them by the Bulgarian majority. This context, and especially the Bulgarian-Roma ethnic tensions, represents an excellent setting where ethnic groups co-exist under the same geographical location but are still separated by "invisible" barriers.

Outgroup attitudes Before the beginning of each experimental session participants were asked to rate their attitudes toward the Roma ethnic group. As in Experiment 4a, I transformed the out-group attitudes variable into two categories: negative and positive/neutral. The number of players assigned to the "positive/neutral" level was 96, while the number of players assigned to the "negative" level was 170. Thus, the sample of ethnic Bulgarian participants exhibited more negative attitudes toward the out-group than the sample of UK Christian participants in Experiment 4a, where the number of players classified as "negative" was 108.

Participants and power analysis For Experiment 4b I recruited 303 participants. Of these participants, 37 were removed as they were unable to answer at least two of the comprehension questions from the quiz correctly. Thus, the final sample consisted of 266 participants (Female = 176, Male = 90), with a mean age of 30.8 years, ranging from 18 to 73 years (SD = 9.16).

The sample size for Experiment 4b was determined based on financial and logistics constraints. A power analysis indicates that the design has a power of $\beta \geq 0.8$ at $\alpha = 0.05$ for an effect size of ≥ 0.31 for the system type variable , ≥ 0.11 for the player type variable, and ≥ 0.22 for the contest type and time constraint variables.

Results and discussion

I executed LME models for all dependent variables of interests. Full results from the models and estimated marginal means (EMM) comparisons can be seen in Appendix D.7. The number of removed decisions for the contribution variable due to slower response in the time pressure condition was 61 or 5.73% of all decisions. The number of removed decisions for the resistance variable was 87 or 8.18% of all decisions. The removed decisions were not imputed.

The LME model for contributions revealed that the player type variable did not yield a statistically significant main effect and was not involved in a statistically significant interaction with contest type, therefore **H1** was not supported by the data. Furthermore, the LME model for expected net benefit revealed the same result, therefore **H2** was also not supported by the data.

The LME model for expected adjusted contributions revealed a main effect of system type, $F(1, 258) = 11.14$, $p < 0.001$, $R^2_{sp} = 0.03$. Players in hierarchical groups had a higher expected adjusted contribution ($M = 57.11$, $SD = 17.3$) than players in egalitarian groups ($M = 50.09$, $SD = 15.34$). As the variable was not involved in a significant interaction, hierarchical groups outperformed egalitarian groups in all cases, contrary to Experiment 4a, where the effect was conditional on the time constraint variable. This result supports **H3**.

Based on the LME model for contributions, contest type was a significantly influential variable, $F(1, 252.05) = 4.02$, $p < 0.046$, $R^2_{sp} = 0.002$. However, contest type was involved in a significant interaction with the gender of participants and their attitudes toward the out-group, $F(1, 252.05) = 6.23$, $p < 0.013$, $R^2_{sp} = 0.003$. A further investigation revealed that only male participants with positive or neutral attitudes toward the out-group contributed more during in-group contests than during out-group contests, $t(243.58) = 3.18$, $p < 0.002$, $d = 0.71$. Therefore, **H4** was not supported by the data, as participants did not contribute more during

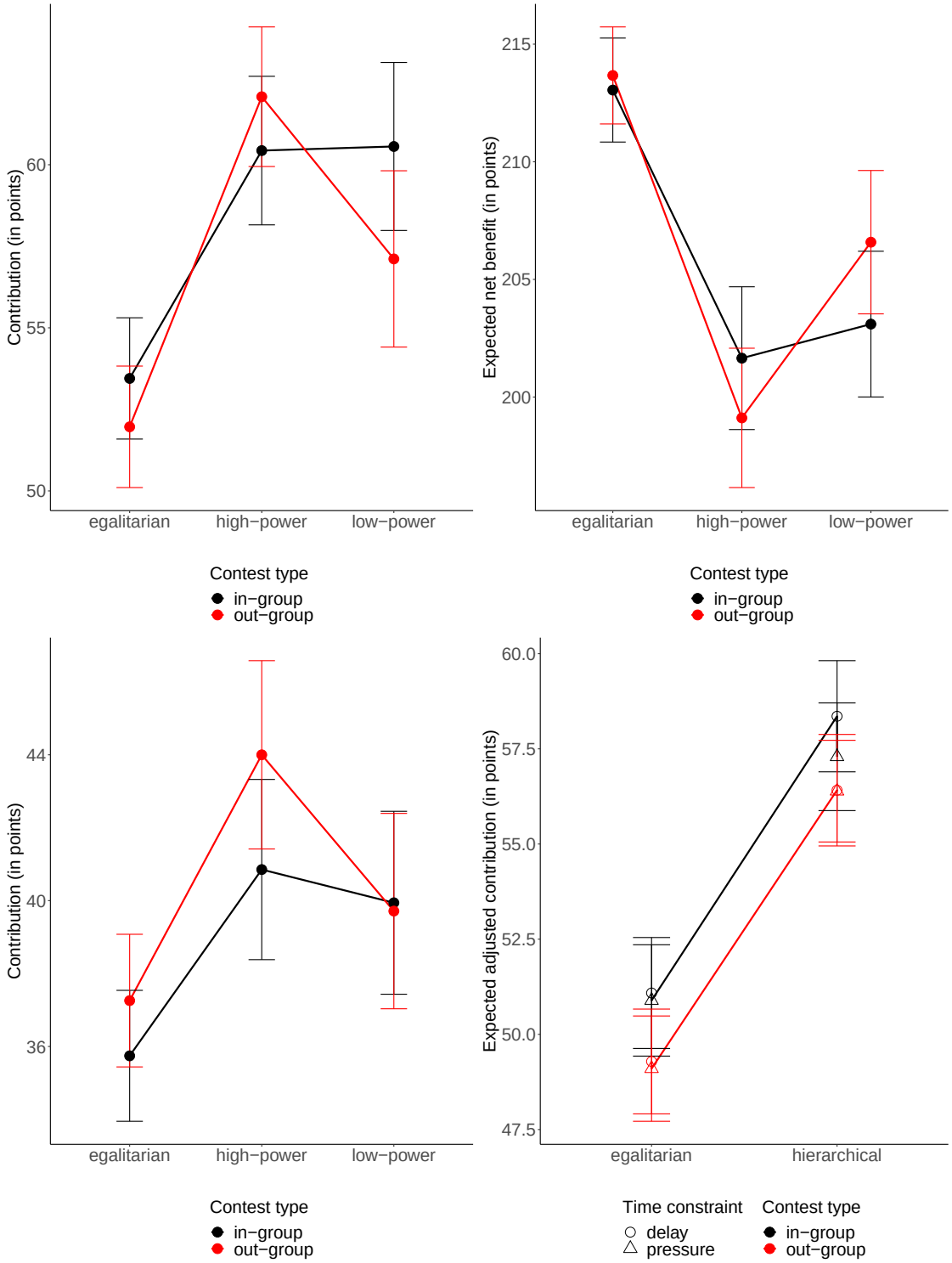


Figure 3.9: Experiment 4b: Contribution, expected net benefit, and resistance by player type and contest type; adjusted contribution by player type, contest type, and time constriant. Hierarchical groups outperformed egalitarian groups. Error bars represent one standard error.

out-group contests than during in-group contests.

Finally, based on the LME model for resistance, the contest type variable did not reveal a statistically significant main effect and was not involved in an interaction, therefore **H5** was not supported by the data.

The models revealed a set of exploratory findings. First, upon visual inspection of Figure 3.9, the tendency was that high-power players contributed more and were more resistant than egalitarian players. Despite the fact that these results were not significant, a contrast comparison revealed that only under out-group contests, high-power players earned statistically less ($EMM = 213.25$, SE = 3.12) than players in egalitarian groups ($EMM = 209.76$, SE = 3.89), t(254) = 2.62, $p < 0.025$, $d = 0.63$. The result replicates findings from Experiment 4a.

Furthermore, concerning the effects of contribution, the player type variable was involved in a significant interaction with gender and out-group attitudes, F(2, 253.75) = 6.46, $p < 0.002$, $R^2_{sp} = 0.03$. An EMM contrasts comparison revealed that female low-power participants contributed significantly more than female egalitarian participants, conditional on their attitudes being on the negative spectrum, t(264.42) = 1.99, $p < 0.048$, $d = 0.82$. Furthermore, female high-power participants contributed significantly more than female low-power participants, if their attitudes were positive or neutral, t(254.73) = 2.41, $p < 0.044$, $d = 1.1$. However, as these conditional exploratory findings were not replicated in Experiment 4a, they should be viewed skeptically.

To summarize, as in Experiment 4a only **H3** was supported by data. However, in this experiment the support was not conditional on the time constraint variable. Again, high-power players did not contribute and did not earn more than low-power players. Furthermore, the contest type did not affect the contribution preferences of players.

3.4 Discussion

In this section I will discuss in more details the findings from the chapter (e.g. from Study 3 and Study 4). A general discussion of all findings connected to the main research questions from all experiments, together with limitations and suggestions for future research, can be found in Chapter 5.

3.4.1 Findings

Findings from both studies for each main research hypothesis can be seen in Table 3.1.

Hypothesis	Study 3	Study 4
H1: High-rank contribute more than low-rank during "us vs. them"	NA	No
H2: High-rank benefit less than low-rank during "us vs. them"	NA	No
H3: Hierarchical groups contribute more than egalitarian during "us vs. them"	NA	Yes (conditional in Study 4a)
H4: More contribution during "us vs. them" than during "us vs. nature"	No	No
H5: Less resistance during "us vs. them" than during "us vs. nature"	No	No

Table 3.1: Results from Study 3 and Study 4 for each of the research hypotheses

Primary findings

There was no significant effect of player type on contribution. The first hypothesis (**H1**) was that high-power (or high-rank) players will contribute more than low-power players during "us vs. them" collective action problems.

To explore this prediction in Study 4 I used a political definition of hierarchy, where player were differentiated based on their ability to influence the decisions of all other group members. Specifically, high-rank individuals were the ones with more power, while low-rank individuals were the ones with less power to influence the contribution preferences of group members. Furthermore, the type of collective action problem was manipulated in a different way from all previous experiments,

as I compared the effect of in-group vs. out-group contests with real social groups (e.g. Christians from the UK and ethnic Bulgarians). The difference between high- and low-power players in terms of contribution was not significant both during in-group and during out-group contests. Thus, **H1** was not supported by the data. Interestingly, this is opposing results from CORR-18 Study 1 and Study 2, where, when hierarchy was defined in economic terms, high-rank individuals contributed more than low-rank individuals in all cases.

Indeed, the difference between the experiments in this chapter and the studies in Chapter 2 are indicative that the effects of rank on contribution may be mediated by the type hierarchy. While economic hierarchy may lead to stronger performance of high-rank individuals, in political hierarchy this may not be the case.

In previous experimental studies with political hierarchy, rank has been based on a specific definition of leadership — namely leaders were said to be players in a public goods game which are allowed to make a first move and to "set an example". In such studies, players who had been assigned to be leaders had been more likely to contribute more in comparison to all other players (Potters et al., 2007; Güth et al., 2007; Kumru & Vesterlund, 2010). Thus, this definition of political rank is thought to increase the contribution preferences of players. However, in this study rank was based purely on the ability of one individual to influence the contribution preferences of another individual (Dahl, 1957; French et al., 1959). Therefore, it adds new results to the body of literature which studies the effects of rank on contribution in collective action problem games. Furthermore, the results suggest that predictions from evolutionary theory, which posit that high-rank individual may contribute more than low-rank individuals during collective action problems, should consider the specific form of hierarchy. Many of these theoretical models aim at a generalized framework, which encompasses multiple forms of hierarchy, such as dominance, strength, and resource hierarchies (Gavrilets & Fortunato, 2014). Further research should aim to study different forms of hierarchy and to explore

the specific conditions under which the theoretical results apply.

There was no effect of player type on net benefit. A second hypothesis (**H2**) was that high-rank players will actually earn less than low-rank players during "us vs. them" collective action problems. Again, this prediction stemmed from the altruistic bully hypothesis, as proposed by Gavrilets and Fortunato (2014).

I tested the hypothesis in Study 4 by using a Monte Carlo simulation to estimate the expected net benefits of players of different ranks. There were no cases in which high-rank individuals, as defined through their power to influence the decisions of other group members, earned significantly and unconditionally less than low-rank players during out-group contests. Only in Experiment 4a did low-power players earn significantly more than high-power, but this was only during in-group contests and was not replicated in Experiment 4b. Thus, results suggest that **H2** was not supported by the data. This result contrasts findings from Study 1 and Study 2, which suggest that in all circumstances high-rank individuals indeed earn more from the strategic interaction than low-rank individuals.

Despite the differences between experiments with economic hierarchy and experiments with political hierarchy, all studies so far did not support the altruistic bully hypothesis. In the political hierarchy studies, increases in contribution and resistance usually lead to decreases in benefit, this suggests that the reason for the lack of a statistically significant difference between the two player types in terms of net benefits may be due to the lack of differences in terms of resistance and contribution.

Hierarchical groups outperformed egalitarian groups in most cases. The third research hypothesis (**H3**) was that hierarchical groups will outperform egalitarian groups during "us vs. them" collective action problems.

To study this question in Study 4, I compared the effect of both system types

on the adjusted expected contribution preferences of players, as estimated from the Monte Carlo simulation. In hierarchical groups, some players had more power to influence the decisions of others, while in egalitarian groups all players had an equal influence over the decisions of all other players. In Experiment 4b hierarchical groups outperformed egalitarian groups both during in-group and during out-group contests. Furthermore, in Experiment 4a this effect was conditional on the time constraint variable. With time delay, hierarchical groups contributed more than egalitarian groups during in-group contest, while with time pressure this was the case during out-group contests. Still, **H3** can be considered supported by the data, but in some cases conditional on the time constraint variable. This goes against experiments from Study 1 and Study 2, which suggest that under economic hierarchy, based on income, egalitarian groups may out-compete hierarchical groups.

The theory behind this hypothesis stemmed from previous theoretical studies within evolutionary biology which suggest that groups with steeper hierarchies may outperform groups with flatter ones, mainly due to increased contribution preferences of high-rank individuals (Gavrilets & Fortunato, 2014; Gavrilets, 2015, 2014; Makowsky & Smaldino, 2016). However, in the case of both experiments in Study 4, there was no statistically significant difference between high-power and low-power players. Therefore, the only remaining explanation in this case is that players in egalitarian groups have a diminished overall contribution in comparison to players in hierarchical groups. Furthermore, the difference between the experiments in this chapter and the experiments in the previous chapter suggests that the effect of the system type on group effort may be conditional on the type of hierarchy. I will further discuss this proposal in Chapter 4, where I compare results across all experiments.

Contest type did not affect significantly the contribution preferences of players. Across both Study 3 and Study 4, I explored whether the type of collective action problem will affect the contribution preferences of players.

More specifically, the main hypothesis (**H4**) was that "us vs. them" problems will increase the amount of contribution of players in comparison to "us vs. nature" problems or less severe "us vs. them" problems, thus helping the group to solve the collective action problem at hand.

In Experiment 3a, I compared inter-group contests vs. control contests. The only difference between the two conditions was the out-group salience. In Experiment 3b, I compared less difficult vs. more difficult inter-group contests. In both cases, these manipulations did not change the contribution preferences of players. To increase the strength of the manipulations, I went beyond minimal groups, based on simple manipulation of group salience, and in Experiment 4a and Experiment 4b I compared the effects of in-group vs. out-group contests on contribution, which again did not influence the contribution preferences of players. Therefore, **H4** was not supported by the data.

This result suggests that the effect of contest type may not be an influential variable for the contribution preferences of players. Previous theoretical positions within behavioural economics and evolutionary theory suggest that we have evolved a set of conditional decision-making preferences, which prioritize in-group members over out-group members, especially during competition (Tajfel, 1982; Yamagishi et al., 1999; Bowles, 2009). Results from Study 3 and Study 4 do not support this hypothesis, at least with the definitions of "us vs. them" collective action problems used across experiments. Furthermore, these results echo findings from Study 1 and Study 2, presented in the previous chapter.

There may be multiple reasons for the null effect of contest type — one being that the manipulations were not strong enough. The manipulations in Study 3 were based on the minimal group paradigm, where participants were assigned to groups randomly. In Study 4, participants were assigned to groups based on their religious or ethnic affiliation, thus I expected this manipulation to produce a stronger effect. Furthermore, one difference between Experiment 4a and Experiment 4b was in the

amount of out-group antgonism between the competing groups. In Experiment 4a the number of UK Christian players which were positive/neutral toward UK Muslim players was 274, while the number of players which were negative was 108. In the sample of Bulgarian participants, 96 were positive/neutral toward the Roma minority, while 170 were negative. Thus, despite the fact that the number of people with negative attitudes increased between studies, the manipulation was not enough to observe the effect of interest. Future research should aim to use stronger manipulations (for instance groups in war or real-world competition).

Contest type did not affect the resistance preferences of players. A final expectation (**H5**), novel for this chapter, was that "us vs. them" collective action problems will decrease the resistance preferences of players in comparison to "us vs. nature" or less sever "us vs. them" collective action problems.

To test this hypothesis, I used the same manipulations of contest type to study the resistance preferences of players across both studies. Neither of the collective action problem manipulations changed the resistance preferences of players. Therefore, **H5** was not supported by the data.

As previously discussed, this hypothesis stemmed from the idea that if hierarchical groups out-perform egalitarian groups during "us vs. them" collective action problems, as suggested by theoretical models (Makowsky & Smaldino, 2016; Gavrilets & Fortunato, 2014), this may have led to the evolution of conditional preferences for resistance. When the problem is "us vs. them", participants may be less resistant toward hierarchy in comparison to cases where the problem is "us vs. nature". There are several possible interpretations of the null result. First, as usual, it may be indeed the case that there is no such change in preferences in the human behavioural repertoire. Second, it may be possible that the manipulation of conflict was not strong enough and thus unable to trigger the conditional resistance preferences of players, as discussed in the previous paragraph. Future

research should aim to use different definitions of the collective action problem type, potentially with stronger manipulations, such as competitions between groups that have an ongoing conflict.

Secondary findings

There were no unconditional effects of gender and time constraint on contribution. In both Study 3 and Study 4, gender did not produce a significant main effect on contribution. Furthermore, the contribution preferences of male and female participants did not usually change as a function of the type of collective action problem faced by their respective groups. Only in Experiment 4a did male participants contribute more than female participants, however, this was conditional on the player type and applied to high-power players only. Thus, the male warrior hypothesis (Vugt et al., 2007; McDonald et al., 2012) was generally not supported in these studies, similarly to Study 1 and Study 2.

Regarding time constraint, Experiment 4a revealed a main effect of this variable, as time pressure increased the contribution preferences of players. However, this effect was mainly driven by a specific sub-type of players — male high-power participants playing out-group contests. The effect of the variable on contribution was not unconditionally statistically significant in Study 3 and Study 4, similarly to Study 1 and Study 2. This result suggests that, at least in contest games, the intuition of participants does not differ from their deliberative responses, as suggested by theoretical models (Bear & Rand, 2016) and meta analyses (Rand & Kraft-Todd, 2014; Rand, 2016).

High-power players were sometimes more resistant than players in egalitarian groups. Furthermore, they earned less than egalitarian players. In Experiment 4a, the player type variable significantly influenced the resistance preferences of players. High-power players in hierarchical groups were more resistant

than players in egalitarian groups. However, this result was not replicated in Experiment 4b, thus it should be taken with a grain of salt.

An interesting difference found in the study was that high-power players in hierarchical groups earned less than players in egalitarian groups. This effect was replicated both in Experiment 4a and in Experiment 4b. However, in Experiment 4b this effect only occurred during out-group contests. Qualitatively, high-power players contributed more and were more resistant than egalitarian players in both experiments, despite the fact that these differences were not significant. Based on the experimental setup, increase in contribution or resistance significantly reduced the net benefits of players. Thus, one possible interpretation for this result is that the non-significant increases in contribution and resistance together produced the reduced net benefit of such players in comparison to players in egalitarian groups. Interestingly, this result has not been predicted by the theoretical literature, thus I am unable able to offer an evolutionary account of these findings.

There were conditional effects of the economic system type on contribution and resistance. The only result from Experiment 3a in terms of contribution was that male participants exerted more effort in egalitarian economic systems than in hierarchical economic systems under time pressure when playing inter-group contests. This effect was not the case for female participants. Thus, the effect of economic hierarchy on contribution may be dependent on the gender of participants. In terms of resistance preferences, the main finding from Experiment 3a was that low-power players were more resistant toward the high-power player in his/her group if s/he was to receive a bonus of 200 points upon winning. This finding is in line with previous literature which suggests that humans have an inequality aversion bias (C. T. Dawes et al., 2007; Blake et al., 2015). In these inequality aversion experiments players were placed in unequal economic system. However, they adjusted their decisions to reduce the inequality, by paying to make poor

people wealthier and wealthy people poorer. Nevertheless, the results in this chapter extend previous findings by making an argument that players are not only willing to pay to reduce the rank of the high-rank player, but are also more willing to pay to reduce his/her power over them. Still, further research is needed, as the finding was conditional on the time constraint variable and was discovered during an exploratory contrast comparison. Therefore, I urge the reader for a skeptical interpretation.

Participants exhibit higher contribution than resistance preferences A novel finding from both experiments is that participants exhibited a high degree of resistance preferences in the first place. More specifically, the mean resistance in Experiment 3a was 34.64 points, while the mean resistance in Experiment 3b was 29.61 points. The mean contribution preferences of players, on the other hand, were 68.22 and 58.75, respectively. Similarly, in Experiment 4a the UK participants used on average 40.52 points from their resistance pots, while the Bulgarian participants used on average 39.03 points. The contribution preferences were higher for both populations (57.53 and 56.77 respectively). This result suggests that (i) participants may exhibit baseline levels of resistance, conditional on the specific manipulation I am using in this study and (ii) our propensity to contribute during collective action problems may be stronger than our propensity to resist the hierarchy.

3.4.2 Conclusions

In summary, the second empirical chapter of this thesis adds novel findings to my inquiry on the interaction between hierarchy and "us vs. them" collective action problems. First, across all experimental studies the type of collective action problem did not influence the contribution and resistance preferences of players. Furthermore, unexpectedly, in Study 4, the rank of participants did not influence the contribution preferences and net benefits of players. However, as expected, the overall adjusted contribution of players in hierarchical groups was significantly higher than that of

players in egalitarian groups. In the next chapter of this thesis I will combine findings from all experiments in a set of meta comparisons, which will allow me to draw more generalizable conclusions. Moreover, in Chapter 5, I will discuss in more detail the implications of the findings for the evolutionary and game theoretic literature.

4

Meta comparisons

4.1 Introduction

Social organisms engage in collective action over various resources. These situations, which are recurrent over human evolution, represent problem for the individual in a form of a social dilemma (R. M. Dawes, 1980). Collective action problems (Olson, 1965) happen when the individual has to decide whether s/he wants to exert effort by incurring cost on himself or to free-ride and try to maximize his/her individual benefit. Both theoretical models and empirical studies suggest that individual often prefer to contribute and incur costs on themselves, despite the fact that such decisions are not deemed as rational. Collective action problems can be divided into two categories — "us vs. them" problems, which include direct competition and conflict between groups, for example, over food, territory, or mating opportunities, and "us vs. nature" problems, which include collaborative efforts to secure resources

from the environment, such as hunting, foraging, or jointly building.

The problem of effort during collective action problems has been seen as one of the central problems of evolutionary biology (Rand & Nowak, 2013). Previous mechanisms, which were used to explain the puzzle of cooperation are altruism, reciprocity, reputation, internalized social norms, and third-party punishment (McElreath & Boyd, 2007; Nowak, 2006; Richerson & Boyd, 2005; Bowles & Gintis, 2011). However, a novel addition mechanisms, based on theoretical and empirical advances within evolutionary biology, has highlighted the role of hierarchy (Gilby et al., 2015; M. L. Wilson et al., 2012; Zhuang et al., 2012), especially during "us vs. them" collective action problems (Gavrilets & Fortunato, 2014; Gavrilets, 2015).

Experiments in this thesis, as outlined in Chapter 2 and Chapter 3, revolved around the idea of hierarchy and rank and their effects on individual and group effort. In Study 1 and Study 2 hierarchy was defined in economic terms. Namely, participants of higher rank in hierarchical groups earned more from the strategic situation, while participants in egalitarian groups were earning equally. In Study 3 and Study 4 rank was defined in political terms, and participants of higher rank had higher means to achieve power over other group members. The number of experiments (*8*) allowed me to draw both qualitative and quantitative conclusions about the interventions used. This includes the effects of system type (hierarchical vs. egalitarian groups), rank (higher- vs lower-rank players), collective action problem type ("us vs. them" vs. "us vs. nature"), gender (male vs. female), and time constraint (time pressure vs. time delay), on the contribution and resistance preferences of players, as well as on their net benefits.

The goal of this chapter is to summarize results across all eight experiments covering more than 2300 participants from three national cultures and to provide the reader with conclusions from this thesis which are statistically more sound than results from any individual experiment.

When appropriate, I will include results from studies executed by other authors

to compare them with findings in this thesis. Such analyses were done for the effects of system type and rank on the contribution preferences of players.

When including external studies into the meta analyses, I concentrated my effort on contest game experiments, by disregarding results from the reviewed public goods games studies, for two reasons. First, as discussed previously, contest games always simulate a type of inter-group competition as by definition players are matched in a group to play the game against players from another group. This is not the case in the public goods game. Furthermore, in contest games the reward is probabilistic, as even if one group achieves higher group effort, the reward may still be given to the other group.

As I think that the differences between the two experimental paradigm are sufficient, results from this thesis, derived exclusively in the contest game paradigm, may not be consider indicative or directly comparable to public good game results. Therefore, such comparisons may bias the conclusions of the thesis, which are bounded to the selected experimental paradigm.

In Section 4.2 I will outline my strategy for meta-comparisons. In Section 4.3.1 I will study the meta effect of different player types (rank) and system type on the contribution preferences and net benefits of players. Furthermore, I will analyse the effect of the collective action problem on the contribution and resistance preferences of players. Finally, in Section 4.3.2 I will study the effect of gender and time constraint on contribution.

Overview of results The findings from the meta comparisons suggest that under economic hierarchy, high-rank individuals exerted more effort than low-rank individuals, but the effect does not apply in the case of political hierarchy. The altruistic bully hypothesis was not supported in any of the experiments. Hierarchical groups outperform egalitarian groups only when hierarchy was defined in political terms. When hierarchy was based on income, in almost all cases egalitarian groups

outperformed hierarchical groups. In terms of the collective action problem type, only group penalty (as manipulated in Study 1 and Study 2) had a systematic main effect on the contribution of players. However, the collective action problem type did not influence their resistance preferences in any of the experiments. Finally, neither gender nor time constraint had a systematic effect on the contribution of players.

4.2 Methodology

As mentioned, the main goal of this chapter is to figure out whether any of the aforementioned interventions are consistent when aggregated between experiments. More specifically, I will utilize a meta-analysis as a tool of choice for this research. The goal of all meta-analytical techniques is to combine data from multiple experiments in order to draw a more general conclusion about the effects of interest and to remove potential between-experiment noise. In other words, when combining data from multiple experiments of similar characteristics, this increases the power of the finding.

Meta-analytic framework To summarize the between-study findings of all experiments I estimated the effect size of each variable of interest. I used a standardized indicator of effect size, as the dependent variables were measured in different scales across studies. More specifically, the effect size calculations were based on Cohen's d measurement (Cohen, 1988), which indicates a standardized difference between the two treatment means. For the experiments in this dissertation, all calculations were obtained with a bootstrapping technique, which is more advantageous than exact techniques when the distribution is unknown (Kirby & Gerlanc, 2013). The number of re-samples per calculation was set to 10000. Each resample in the boostrap estimates a sample effect size. The mean of the distribution of all sample effect sizes is the bootstrapped effect size, which is expected to be an empirical approximation of the population effect size. The confidence intervals in this method were then obtained with percentile cut-offs of the distribution, following the bias-corrected-and-accelerated method. The bootstrapping technique was implemented with the R package "BootES" (Kirby & Gerlanc, 2013).

The meta analyses used the calculated effect sizes and standard errors of each experiment to estimate a weighted average effect size (known as the meta-analytic

effect size). The estimation of the weighted average effect size was based on a random-effects model, implemented with the statistical package "metafor" (Viechtbauer et al., 2010) in the R programming language. The random-effects model assumes that there are design-specific differences between each of the studies included in the meta analysis, such as differences in manipulation, population, and/or experimental setting. The meta-analytic effect size and standard error were then used to execute two statistical tests: a standard null hypothesis test, which determines whether the estimated meta-analytic effect size is different from 0, and a meta-analytic equivalence test, which aims to check whether the meta-analytic effect size is significantly bounded between a specific interval (Lakens, 2017). For the meta-analytic equivalence test, I set the upper boundary for the Cohen's d (Δ_U) to 0.2 and the lower boundary (Δ_L) to -0.2. These numbers are equivalent to a small effect size, based on the classification by Cohen (1988), and can be considered of little, if any, practical relevance. All equivalence tests were executed with the R package "TOSTER" (Lakens, 2017).

4.3 Results

In what follows, I will outline all important meta-comparisons regarding the main questions and problems of this thesis.

4.3.1 Primary questions

Rank differences and contribution The first question I raised in this thesis was whether high-rank individuals will exert more effort than low-rank individuals in hierarchical groups, especially during "us vs. them" collective action problems.

The rationale for this question stems both from theoretical predictions and from previous empirical studies. In terms of theory, evolutionary models of contribution have predicted that during "us vs. them" collective action problems, such as inter-group conflict, high-rank individuals in hierarchical groups will exhibit higher contribution preferences than their low-rank counterparts. In fact, in such cases high-rank players are expected to be the sole contributors in their group and their effort to be equivalent to the group effort, while low-rank players are expected to free-ride (Gavrilets & Fortunato, 2014; Gavrilets, 2015). This evolutionary prediction is complemented by theoretical predictions from rational-choice theory, which study how collective action problems are solved by groups in "us vs. nature" settings (Olson, 1965). Overall, models from various disciplines predict that during collective action problems low-rank individuals will exploit high-rank group members.

In Study 1 and Study 2 I tested the effect of rank based on economic income. During the contest games some participants received more from the contest prize (high-rank players), if their group was victorious, while other participants received less (low-rank players). In Study 4 participants were divided based on their political power. Some participants were able to influence the decisions of all other participants more (high-power players), while other participants were able to influence the decisions of all other participants less or were unable to do so (low-power players).

Results from Study 3 were not included in this meta analysis, as the player rank variable was not actually manipulated with regards to individual contributions. In Study 3a low-rank players were led to believe that there are high-rank individuals, while in Study 3b high-rank individuals were asked only to make a power use decision. They were not asked about their contribution preferences.

As seen in Figure 4.1, the effect of rank on contribution differed as a function of the type of hierarchy, under various problem type manipulations. In Study 1 and Study 2 higher-rank players contributed more than lower-rank players in all cases. Thus, during economic hierarchy based on income the research hypothesis was supported by the data. In Study 4, where rank was based on differences in terms of power (e.g. how much players can influence the decisions of all other players), the results were not statistically significant, thus this research hypothesis was not supported by the data.

When results were aggregated for all experiments in the thesis (see Figure 4.2), the meta analysis revealed that the meta-analytic effect size was $d = 0.53$, z $= 2.17$, $p < 0.030$, in favour of the high-rank individuals. Moreover, based on an equivalence meta-analysis, the effect size was not significantly bounded between $\Delta_L = -0.2$ and $\Delta_U = 0.2$, as the larger of the two p-values of the two t-tests was more than $\alpha = 0.05$, t $= 1.36$, $p < 0.912$. Therefore, based on the results from the thesis, high-rank players earned significantly more than low-rank players, if the type of hierarchy is disregarded.

Furthermore, when all results in the thesis were combined in an overall meta analysis with previous contest game experiments, exploring the same research question, although with different definitions of hierarchy, the meta analysis revealed that the meta-analytic effect size was $d = 0.59$, z $= 3.46$, $p < 0.001$. Moreover, based on an equivalence meta-analysis, the effect size was not significantly bounded between $\Delta_L = -0.2$ and $\Delta_U = 0.2$, as the larger of the two p-values of the two t-tests was more than $\alpha = 0.05$, t $= 2.28$, $p < 0.989$. In other words, the result from

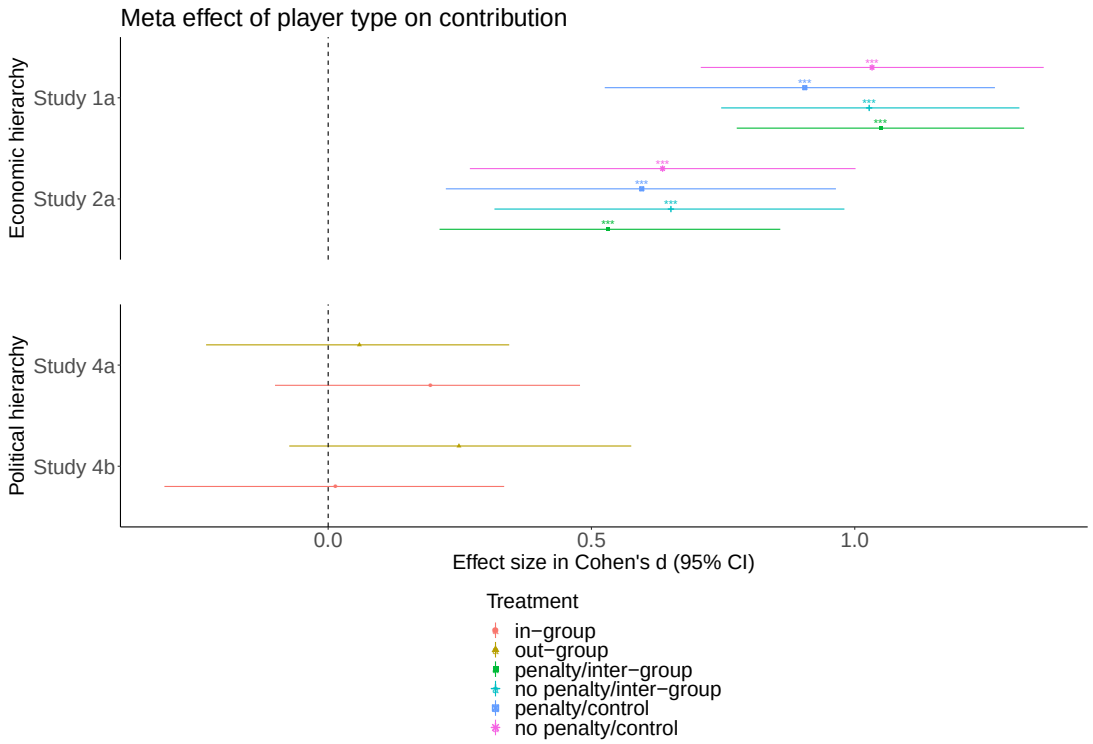


Figure 4.1: Forest plot of the effect size of rank on contribution in each experiment grouped by the problem type variables. Positive effect size indicates more contribution for higher-rank players, while negative effect size indicates more contribution for lower-rank players. Significance is represented as * for $p < 0.05$, ** for $p < 0.01$, and *** for $p < 0.001$.

the thesis that high-rank individuals contribute more than low-rank individuals is in line with findings from other experiments where the effect of rank is manipulated directly, if the type of hierarchy is disregarded.

Rank differences and net benefits The second research question was whether high-rank players will actually earn less than low-rank players during "us vs. them" collective action problems.

This idea stemmed from the altruistic bully hypothesis, developed by Gavrilets and Fortunato (2014). During "us vs. them" problems high-rank players were expected to contribute more than low-rank players. In fact, based on theoretical predictions low-rank players were expected to free ride, making high-rank players the sole contributors in terms of effort to the collective action. In such cases, a

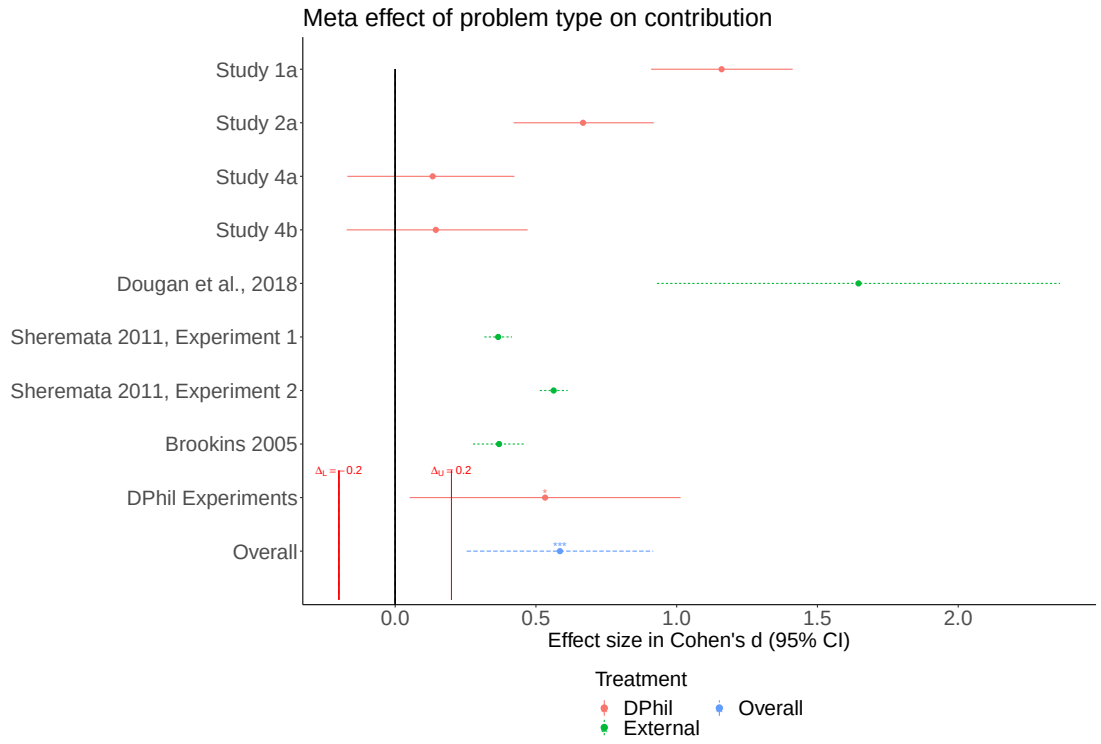


Figure 4.2: Forest plot of the overall effect size of rank on contribution in each experiment. Results from similar experiments are included in the comparison. Positive effect size indicates more contribution for higher-rank players, while negative effect size indicates more contribution for lower-rank players. Significance is represented as * for $p < 0.05$, ** for $p < 0.01$, and *** for $p < 0.001$.

significant increase in the contribution preferences by such players may lead to a reduction of their net benefit. The rationale stems from the nature of collective action problems as social dilemmas, where there is a conflict between individual and collective interest. If we decide to increase our contribution, we increase our group's chance of success but our expected benefit is usually reduced (R. M. Dawes, 1980).

In most experiments I studied the effect of rank on contribution. In Study 1 I measured the net benefits of players from each of their contribution decisions, while in Study 2 and Study 4 I employed a Monte Carlo simulation, which allowed me to estimate the expected net benefit of players over multiple permutations of the actual game. In Study 1 and Study 2 rank was based on economic income, while in Study 4 it was based on political power.

As seen in Figure 4.3, there was a conditional effect of rank on the net benefit

of participants, which mimics the patterns of their contribution preferences. In the case of economic hierarchy, when individuals in Study 1 and Study 2 who earned 40% of the prize were compared with individuals who earned 10% of the prize, the effect was statistically significant. In all cases the 40% players earned more than the 10% players. However, in the case of political hierarchy (Study 4), the difference between high-power players and low-power players was not statistically significant. The only case in which high-rank players earned less than low-rank players was in Experiment 4a, but this was the case with in-group rather than with out-group contests, which was not predicted by theory. Thus, the altruistic bully hypothesis was not supported independently in any of the experimental studies.

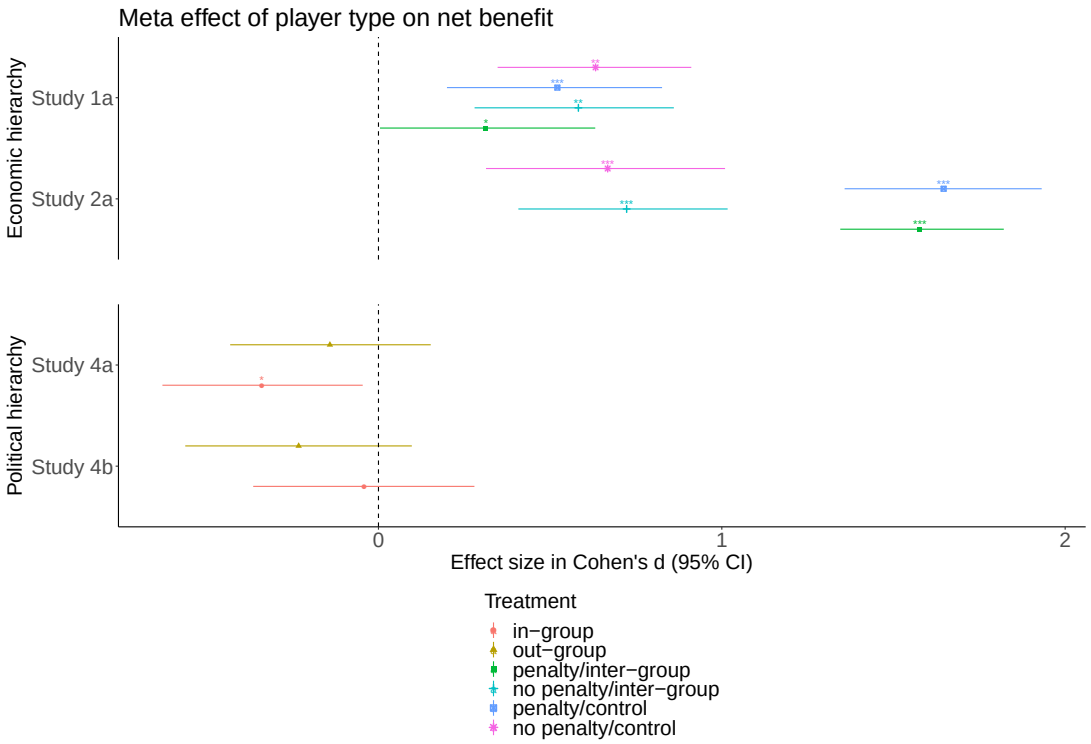


Figure 4.3: Forest plot of the effect size of rank on benefit in each experiment grouped by the problem type variables. Positive effect size indicates more net benefit for high-rank players, while negative effect size indicates more net benefit for low-rank players. Significance is represented as * for $p < 0.05$, ** for $p < 0.01$, and *** for $p < 0.001$.

When results were aggregated for all experiments in the thesis (see Figure 4.4), the meta analysis revealed that the meta-analytic effect size was $d = 0.53$, z =

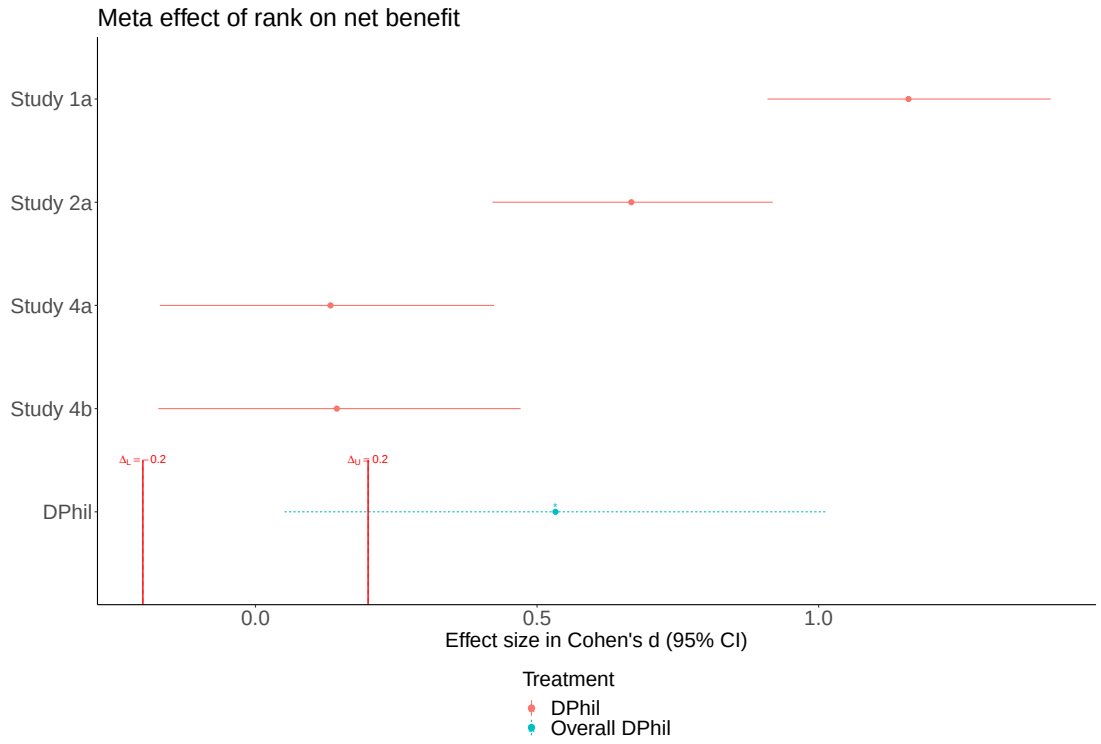


Figure 4.4: Forest plot of the overall effect size of rank on benefit in each experiment. Positive effect size indicates more net benefit for high-rank players, while negative effect size indicates more net benefit for low-rank players. Significance is represented as * for p $<$ 0.05, ** for p $<$ 0.01, and *** for p $<$ 0.001.

2.17, $p < 0.030$. Moreover, based on an equivalence meta-analysis, the effect size was not significantly bounded between $\Delta_L = -0.2$ and $\Delta_U = 0.2$, as the larger of the two p-values of the two t-tests was more than $\alpha = 0.05$, t = 1.36, $p < 0.912$. Therefore, overall, high-rank individuals earned significantly more than low rank individuals, if the type of hierarchy is disregarded from the model.

System type and group effort The third research question was whether hierarchical groups will out-perform egalitarian groups in terms of contribution during "us vs. them" collective action problems.

Multiple frameworks within evolutionary biology have proposed the existence of differences between the performance of hierarchical and egalitarian groups. Groups employing hierarchical structure may have certain benefits over groups employing an egalitarian structure. A hierarchical group structure may motivate

individuals to contribute (Chudek, Heller, Birch, & Henrich, 2012), may help groups resolve internal conflict (Boehm, 2012), may lead to a reduction in the costs of punishment (Baldassarri & Grossman, 2011; O'Gorman et al., 2009) and contribution (Gavrilets, 2015), and may increase in-group coordination (Couzin & Krause, 2003). The positive effects of hierarchical over egalitarian groups have been explored in theoretical models. For instance, Gavrilets and Fortunato (2014) have shown that during "us vs. them" collective action problems hierarchy leads to higher group effort, due to increase in individual effort by the high-rank individuals. This result has been replicated in other theoretical work as well (Gavrilets, 2015, 2014). Furthermore, evolutionary models which employ a political definition of hierarchy (e.g. based on the ability of one or more individuals to influence the decisions of other group members) and connectedness-based definitions (where high-rank individuals are more connected in a social network) reached similar conclusions (see Makowsky and Smaldino (2016) and Santos et al. (2008) respectively).

To study this prediction, in Study 1 and Study 2 I devised experiments which manipulated the system type of the group, by placing participants either in economic hierarchy or not. In Study 4 players were placed in political hierarchy or not. Experiment 3a included a manipulation of the type of economic hierarchy. However, in the study only low-rank players were asked to make contribution decisions. Furthermore, they were led to believe that there are indeed high-rank players, while in fact this constituted a deception. As the rationale for the aforementioned hypothesis that hierarchical groups will out-compete egalitarian groups was underlined by an expectation for an increased contribution of high-rank players (and such players did not exist in the study), I decided to remove the Experiment 3a from this meta analysis.

Based on the data, as seen in Figure 4.5, the effect of system type on contribution was again conditional, similarly to the effect of rank on contribution and net benefits. In Study 1 and Study 2 in almost all cases egalitarian groups outperformed

hierarchical groups. The only exception was in Study 1, where the difference between the two system types was not significant during control contests without group penalty (e.g. during "us vs. nature" problems). In Study 4 the result was reversed, as in Experiment 4b in all cases hierarchical groups outperformed egalitarian groups, while in Experiment 4a this was the case during in-group contests (conditional on time delay) and during out-group contests (conditional on time pressure).

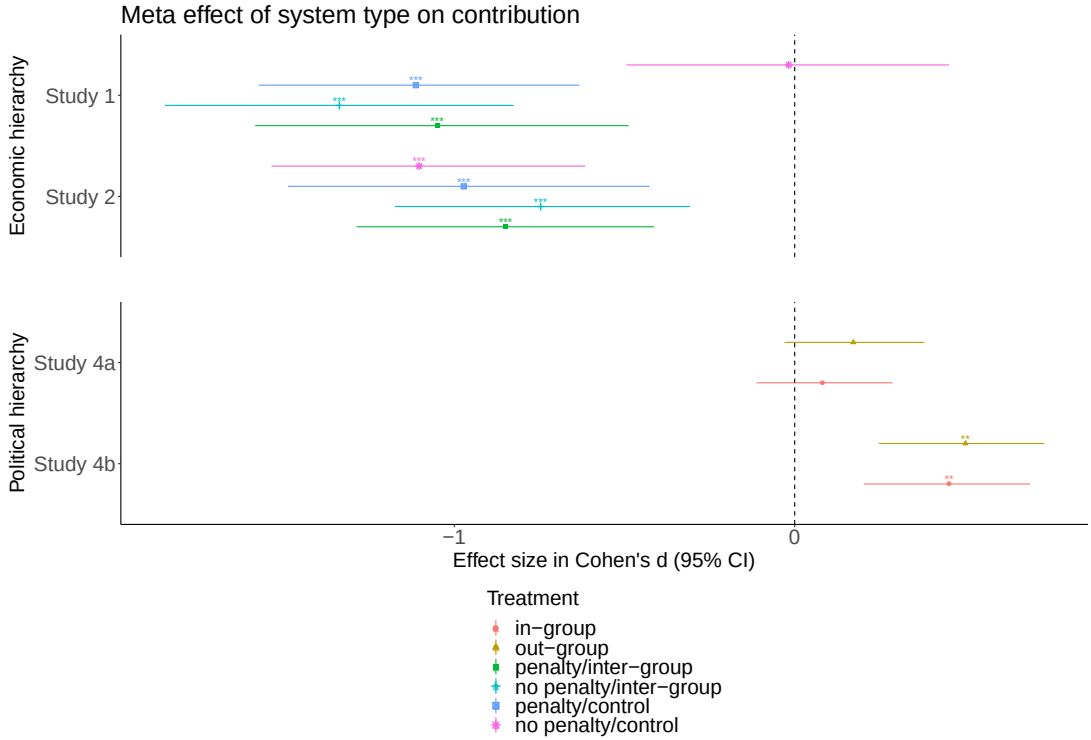


Figure 4.5: Forest plot of the effect size of system type on group contribution in each experiment grouped by the problem type variables. Positive effect size indicates more contribution for hierarchical groups, while negative effect size indicates more contribution for egalitarian groups. Significance is represented as * for p $<$ 0.05, ** for p $<$ 0.01, and *** for p $<$ 0.001.

When results were aggregated for all experiments in the thesis (see Figure 4.6), the meta analysis revealed that the meta-analytic effect size was d =-0.286, z = -0.766, $p < 0.444$. Therefore, the effect of the system type variable of contribution was not significant. Furthermore, based on an equivalence meta-analysis, the effect size was not significantly bounded between $\Delta_L = -0.2$ and $\Delta_U = 0.2$, as the larger of the two p-values of the two t-tests was more than $\alpha = 0.05$, t = -0.23, $p < 0.591$.

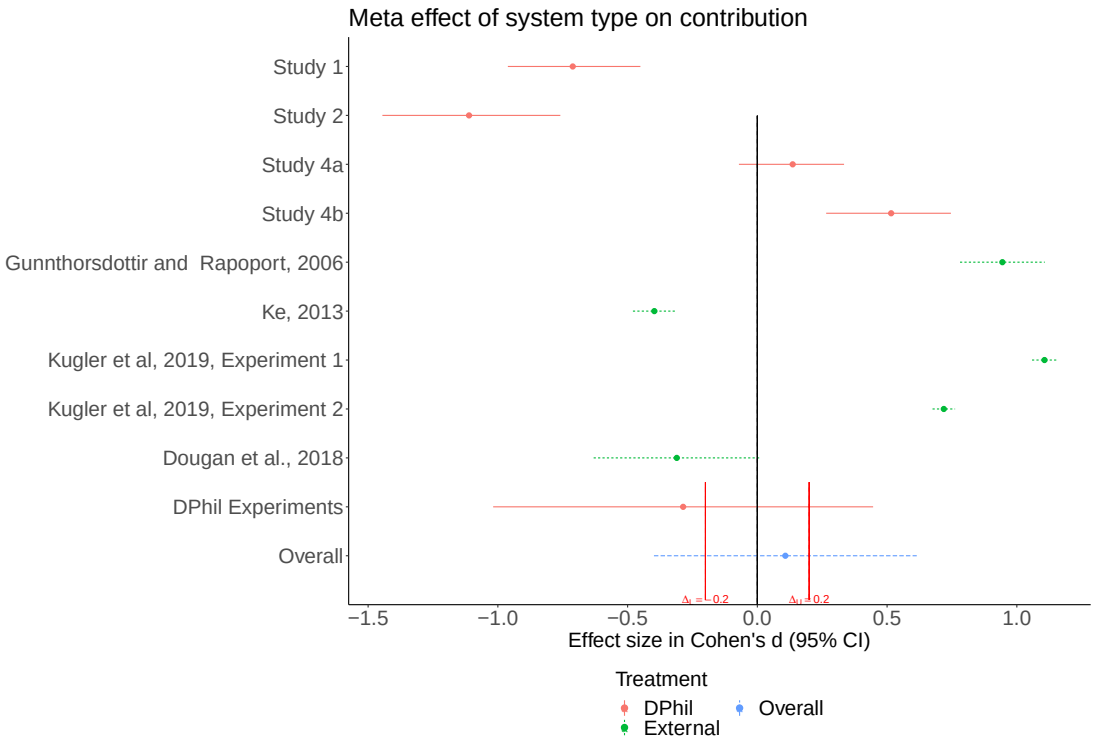


Figure 4.6: Forest plot of the overall effect size of system type on group contribution in each experiment. Results from similar experiments are included in the comparison. Positive effect size indicates more contribution for hierarchical groups, while negative effect size indicates more contribution for egalitarian groups. Significance is represented as * for $p < 0.05$, ** for $p < 0.01$, and *** for $p < 0.001$.

In other words, based on the results from the thesis, the system type (hierarchical or egalitarian) did not influence significantly the contribution levels of participants and groups, when the type of hierarchy is disregarded.

Furthermore, when all results in the thesis were combined in an overall meta analysis with previous contest game experiments exploring the same research question, the meta analysis revealed the meta-analytic effect size was $d = 0.11$, which was again not significant, z = 0.42, $p < 0.676$. Based on an equivalence meta-analysis, the effect size was again not significantly bounded between $\Delta_L = -0.2$ and $\Delta_U = 0.2$, as the larger of the two p-values of the two t-tests was more than $\alpha = 0.05$, t = -0.356, $p < 0.361$. As a result, if we do not look more closely into the type of hierarchy, the overall effect of the system type variable was not significant.

However, the differences between the two types of hierarchy are important and

may have multiple explanations. A closer look at the contribution preferences of players may be more indicative. Figure 4.7 represents the contribution preferences as a percentage across all studies where the player type variable has been manipulated. As seen from the figure, in Study 1 and Study 2 the reduction of contribution of hierarchical groups was mainly driven by the relative reduction of the lower-rank players' contribution. The contribution of the 40% players in Study 1 and the high-rank players in Study 2 was similar to the contribution of egalitarian players. However, the contribution of low-rank players was diminished in comparison to the other two player types. On the other hand, in Study 4 the contribution of players in egalitarian groups was similar or were lower than the contribution of the players in hierarchical groups. In other words, the reduced effort of hierarchical groups during economic hierarchy may be mainly driven by the reduced effort of the low-rank players.

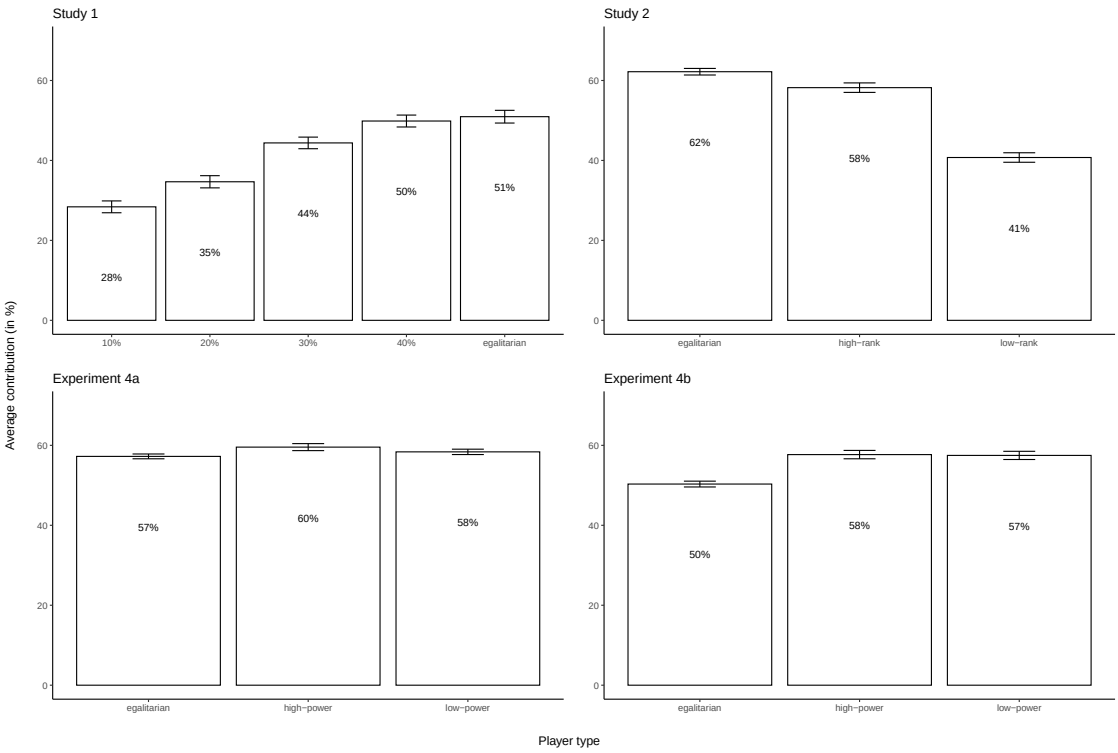


Figure 4.7: Contribution (as percentage) per player type in Study 1, 2, and 4. Error bars represent one standard error.

Collective action problem and individual effort The fourth research question was whether the type of collective action problem will influence the contribution preferences of players. Inter-group conflict and competition (e.g. "us vs. them" problems) have been seen as an important driver of human evolution. Evidence from ethnographic research with extinct and extant hunter-gatherers (Glowacki et al., 2017; Binford, 2001), from comparative studies with non-human primates (Glowacki et al., 2017; Rosenbaum et al., 2016), and from behavioural and cognitive experiments with human participants (Hewstone et al., 2002; Everett, Faber, & Crockett, 2015; Bauer et al., 2016) suggests that humans may exhibit a propensity to categories the social world into "us" and "them" (Hart et al., 2000; Van Bavel et al., 2008). Furthermore, humans and other genetically related species, such as the chimpanzees, exhibit raiding behaviour, characterized by low-risk lethal aggression toward out-group members (Gat, 2008; Glowacki et al., 2017). Gorillas, on the other hand, exhibit a form of lethal aggression toward out-group members, especially individuals which are in close proximity to the focal group (Rosenbaum et al., 2016). These findings have given rise to evolutionary conceptualizations of inter-group conflict, such as the theory of parochial altruism, which claim that humans have evolved biases against out-group members and have adjusted their contribution preferences accordingly (Choi & Bowles, 2007; Bowles, 2009). Taken together, all these ideas suggest that humans may have evolved mechanism to solve "us vs. them" collective action problems, which lead to increased contribution preferences during conflict or competition.

I have studied this prediction across all experiments. In Study 1, Study 2, and Experiment 3a I tested inter-group contests vs. control contests. This manipulation was based on the minimal groups paradigm, which emphasizes the salience of the out-group. Furthermore, in Study 1 and Study 2 I explored whether a different type of "us vs. them" problem, group penalty, will affect the contribution preferences of players. In Experiment 3b I tested whether the difficulty of the "us vs. them"

collective action problem will be influential, while in Study 4 I explored the effect of in-group vs. out-group contests with real social groups (e.g. UK Christian vs. UK Muslim and ethnic Bulgarian vs. ethnic Roma).

As shown in Figure 4.8, the effect of the type of collective action problem varied between manipulations. The main manipulation which significantly changed the contribution preferences of players across experiments was group penalty. In Experiments 1a/b and Experiments 2a/b the introduction of group penalty increased contributions in comparison to contests without group penalty. The in-group vs. out-group contest manipulation was influential in Experiment 4a only, where in-group contests led to more contributions than out-group contests. However this effect was driven by male players with positive out-group attitudes only. The contest type manipulation (e.g. inter-group vs. control contests) did not influence significantly the contribution preferences of players in any of the experiments. Furthermore, an equivalence test revealed that the effect of this variable was significantly bounded between $\Delta_L = -0.2$ and $\Delta_U = 0.2$, as the larger of the two p-values of the two t-tests was less than $\alpha = 0.05$, t = -3.249, $p < 0.001$. Thus, the effect of this manipulation was smaller than the bound and can be considered of limited practical importance.

Collective action problem and resistance Related to the previous research question, the next question, which I raised only in Study 3 and Study 4, was whether the resistance preferences of individuals change as a function of the type of collective action problem they are facing. More specifically, I hypothesised that participants would be less resistant during "us vs. them" collective action problems than during "us vs. nature" collective action problems.

The rationale behind this hypothesis stems from the idea that hierarchical groups, at least during the human environment of evolutionary adaptedness, may have been better at solving "us vs. them" collective action problems, according to several theoretical accounts (Gavrilets & Fortunato, 2014; Makowsky & Smaldino,

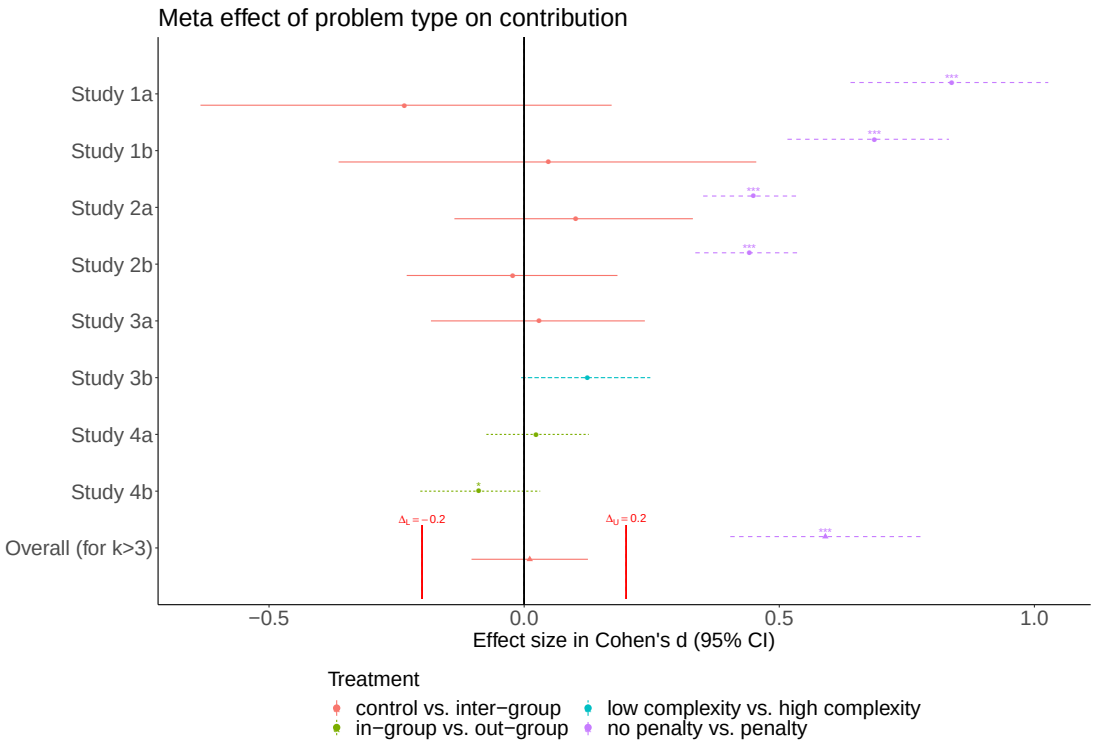


Figure 4.8: Forest plot of the effect size of collection action problem type on contribution in each experiment. Positive effect size indicates more contribution during inter-group/group penalty/high difficulty/out-group games, while negative effect size indicates more contribution during control/no penalty/low difficulty/in-group games. Significance is represented as * for $p < 0.05$, ** for $p < 0.01$, and *** for $p < 0.001$.

2016). In such cases, hierarchical groups provide a set of advantages for the group's success over egalitarian groups, as previously discussed in Chapter 1. Due to these advantages, the expectation is that humans may have evolved a conditional decrease in resistance against hierarchy, when the collective action problem is "us vs. them", in comparison to cases when the problem is "us vs. nature". Therefore, evolutionary logic hints that human resistance preferences change as a function of the type of collective action problem.

I tested this expectation in four of the presented experiments. In Experiment 3a I compared the effect of inter-group contests vs. control contests, while in Experiment 3b I compared the effect of more difficult inter-group contests vs. less difficult inter-group contests. In Study 4 I compared the effect of in-group vs. out-group contests on the resistance preferences of players both with UK Christian

participants supposedly playing against UK Muslim participants and with Bulgarian participants supposedly playing against Roma participants.

In all experiments I was unable to support this hypothesis, as seen in Figure 4.9. In all cases the type of collective action problems did not affect the resistance preferences of players.

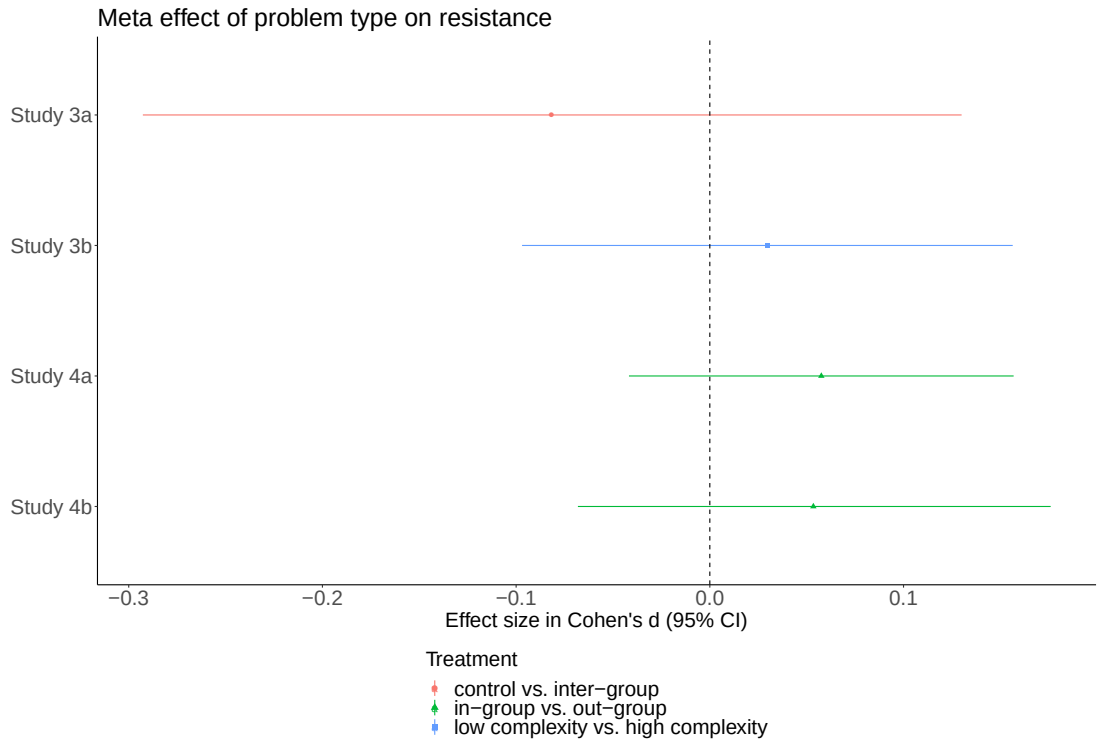


Figure 4.9: Forest plot of the effect size of collection action problem type on resistance in each experiment. Positive effect size indicates more resistance during inter-group/high difficulty/out-group games, while negative effect size indicates more resistance during control/low difficulty/in-group games. Significance is represented as * for $p < 0.05$, ** for $p < 0.01$, and *** for $p < 0.001$.

4.3.2 Secondary questions

Gender and individual effort In terms of secondary findings, across all experiments I explored the effects of gender on contribution. The goal was to see whether (i) gender affects the contribution preferences of players and (ii) to explore further the male warrior hypothesis. The male warrior hypothesis suggests that male participants will out-perform female participants in terms of contribution during

"us vs. them" problems (Vugt et al., 2007; McDonald et al., 2012), as men may have evolved specific psychological mechanisms for alliance and coalition formation. This hypothesis has been supported by previous experimental studies showing that during competition male players contribute more than female players (Vugt et al., 2007).

To investigate these questions, I included gender as an independent variable in all statistical models. Only in Study 1 I did not interact the gender variable with all other independent variables, as some participant answered "Other" to the gender question, which made the number of data points for this level of the variable insufficient for an interaction analysis.

Across all experimental studies, gender was rarely an influential variable. It usually produced only conditional effects, as part of significant interactions. As shown in Figure 4.10, gender did not produce a statistically significant main effect in any of the experiments. Moreover, based on an equivalence meta-analysis, the effect size of gender was significantly bounded between $\Delta_L = -0.2$ and $\Delta_U = 0.2$, as the larger of the two p-values of the two t-tests was less than $\alpha = 0.05$, t = -4.247, $p < 0.001$. Therefore, we can assume that if an effect of gender on contribution exists, it is likely smaller than ± 0.2 and of little practical importance.

In terms of the male warrior hypothesis, the effect of gender was not significant during most of the "us vs. them" collective action problem manipulations used in this project. There were several notable exceptions, as in Experiment 2a female participants contributed more than male participants during inter-group contests under group penalty, while in Experiment 4a male participants contributed more than female participants during in-group contests (however, this effect was conditional on them being with positive or neutral attitudes toward the out-group).

Cognitive processing and individual effort As a second exploratory component of this thesis, I studied the effects of time constraint on contribution. This allowed me to compare the intuitive vs. the deliberative decisions of players

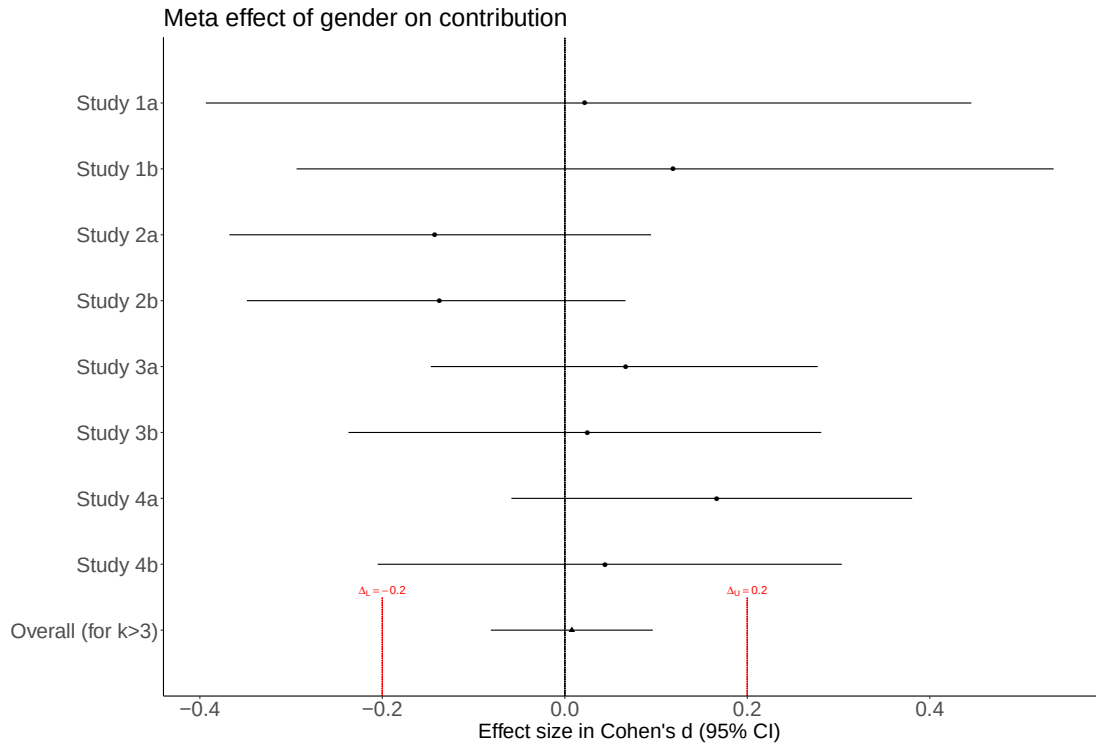


Figure 4.10: Forest plot of the effect size of gender on contribution in each experiment. Positive effect size indicates more contribution for male participants, while negative effect size indicates more contribution for female participants. Significance is represented as * for $p < 0.05$, ** for $p < 0.01$, and *** for $p < 0.001$.

(Kahneman, 2011). Based on evolutionary theory (Bear & Rand, 2016) and meta analyses (Rand & Kraft-Todd, 2014; Rand, 2016), previous research has predicted that the intuitive preferences of participants will be to contribute, especially if the situation is pure and players or groups of players will not interact with each other in the future.

I approached this problem by utilizing two different manipulations. In Experiment 1a/b I compared time pressure vs. no time pressure, while in all remaining experiments I compared time pressure vs. time delay.

As seen in Figure 4.11 the effect of time constraint was not significant in most experimental studies. Only in Experiment 4a participants contributed more under time pressure than under time delay. However, the effect in this study was mainly driven by male high-rank players playing out-group contests (e.g. the effect was

involved in an interaction). As the time pressure vs. time delay manipulation was applied in six of the studies, I executed a meta-analytical equivalence test, which revealed that the effect size was significantly bounded between $\Delta_L = -0.2$ and $\Delta_U = 0.2$, as the larger of the two p-values of the two t-tests was less than $\alpha = 0.05$, t = -5.976, $p < 0.001$.

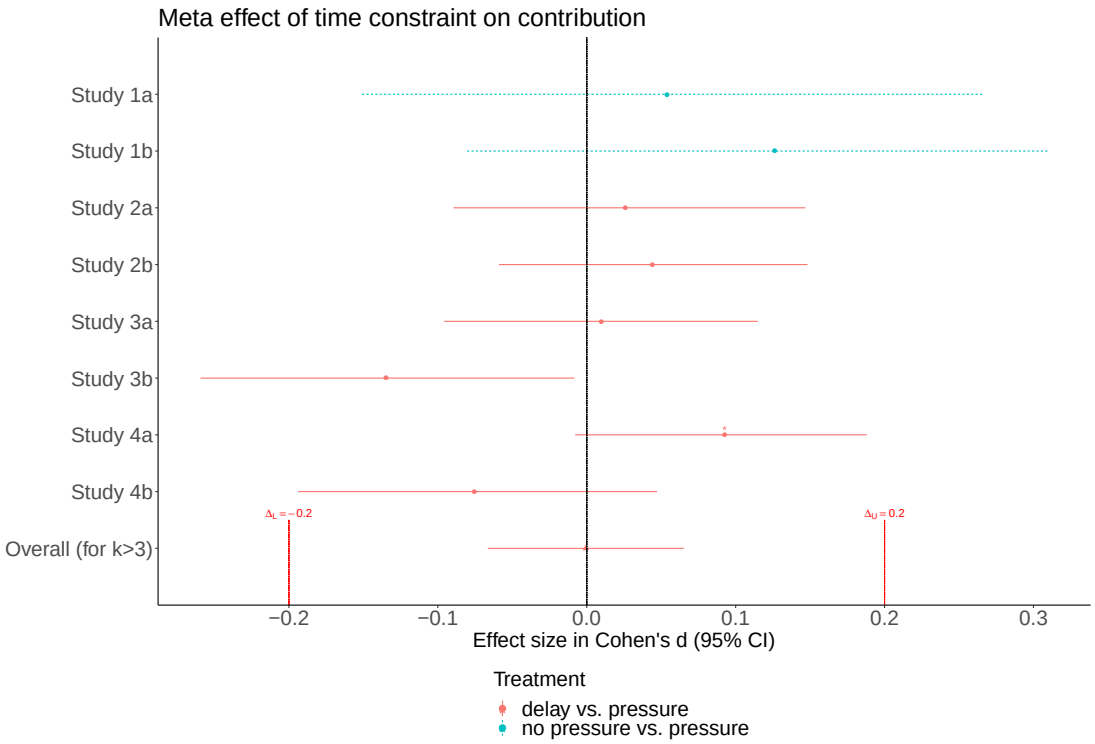


Figure 4.11: Forest plot of the effect size of time constraint on contribution in each experiment. Positive effect size indicates more contribution during time pressure, while negative effect size indicates more contribution during time delay/no time pressure. Significance is represented as * for p $<$ 0.05, ** for p $<$ 0.01, and *** for p $<$ 0.001.

4.4 Conclusions

Findings In this section I will summarize the findings and the main methodological limitations of the meta analyses. I will discuss the results in more details in Chapter 5. Findings from the chapter are the following:

1. Rank influenced the contributions of participants only in hierarchical groups defined in economic terms;

2. Rank did not influence the benefits of participants;

3. Hierarchical groups outperformed egalitarian groups only when hierarchy was defined in political terms. When hierarchy was based on income, the effect was usually reversed;

4. The type of collective action problem ("us vs. them" vs. "us vs. nature") did not influence the contribution preferences of players in most cases. Only the group penalty definition of "us vs. them" problems was influential;

5. The type of collective action problem did not influence the resistance preferences of players;

6. There were no meaningful effects of gender and time constraint on contribution.

In terms of the effects of rank on contribution, when the results were aggregated between experiments, by disregarding the type of hierarchy, high-rank individuals were shown to exert more effort than low-rank individuals. Furthermore, this result was replicated even when experiments from different forms of hierarchy, mainly based on redistribution of the contest prize proportional to the effort, were included in the meta-analysis. However, when zoomed in, the limited experimental evidence so far on this topic suggests that rank affects the contribution level of participants only if it was based on economic discrepancies. In all experiments where hierarchy was defined in economic terms, the effect was positive in favor of the high-rank

players. However, in the two studies presented in this thesis, when rank was defined in political terms, the effect was not significant. This finding suggests that economic hierarchy may widen the discrepancies between different player ranks, but this effect was most likely due to reduced contribution of the low-rank players, not because of increased contribution of the high-rank participants, as predicted by previous theoretical models (Olson, 1965; Gavrilets & Fortunato, 2014; Gavrilets, 2015, 2014).

In terms of rank's effects on benefit, the altruistic bully hypothesis, as proposed by Gavrilets and Fortunato (2014), was not supported by data. Namely, low-rank players never earned more than high-rank players. A meta-analysis, which combines data from all four experiments, suggests that the average effect size was positive in favor of the high-rank players.

In terms of the effect of system type on group effort, when results from previous experiments were combined, the average effect size was not statistically significant. However, under political hierarchy, as studied in Study 4, hierarchical groups often out-performed egalitarian groups, while under economic hierarchy based on income, egalitarian groups out-performed hierarchical groups. In previous experiments with economic hierarchy based on proportional redistribution of the contest prize, the results were roughly split.

Subsequent analyses presented in this chapter suggest that this effect may be driven mainly by diminishing effort by low-power players in groups with economic hierarchy. One possible explanation for this effect is that such players exhibit fairness considerations (Fehr & Schmidt, 1999, 2000, 2010), as they may judge the strategic situation as "unfair" and may sabotage the group effort. A second possibility is that the strategic situation activates participants' inequality aversion preferences (C. T. Dawes et al., 2007; Blake et al., 2015), as they may aim to minimize the differences in the group. Still, these proposal are to be tested by further research and are outside the scope of this experimental work. The type of collective action problem did not affect the resistance preferences of players

either. As this hypothesis was novel to the thesis and was never tested with a power-based manipulation of hierarchy, many possible methodological explanations can account for the lack of significant findings, including weak manipulations or unrealistic "us vs. them" settings. Further research should aim to replicate the experimental logic with novel manipulations.

Moreover, the collective action problem type was not always an influential variable, as predicted by theoretical models (Choi & Bowles, 2007; Bowles, 2009) and as seen in previous studies (Hewstone et al., 2002; Everett, Faber, & Crockett, 2015; Voors et al., 2012; Gilligan et al., 2014; Bauer et al., 2017). When only group salience was manipulated, e.g. when participants were playing in the minimal groups paradigm or when they were told that they will play against players from an antagonistic group, the effect was not significant. However, when participants were likely to lose resources when the performance was low, e.g. during the group penalty manipulations, the individual effort of players increased, similarly to previous findings with experimental tournaments (Böhm & Rockenbach, 2013; Tan & Bolle, 2007; Burton-Chellew & West, 2012).

Finally, in terms of gender and time constraint, average effect size of the two variables approached zero and a meta-analytic equivalence test revealed that it is highly likely that the effect is of no practical relevance, if at all there. These results suggest that the contribution levels of players, at least in the contest game paradigm, are not affected by a dual-processing manipulation and the intuitive decision may be similar to the deliberative decision, as predicted by models (Bear & Rand, 2016) and previous experiments (Rand et al., 2012; Rand & Kraft-Todd, 2014; Rand, 2016; Sutter et al., 2003; Cappelletti et al., 2011; Cone & Rand, 2014; Neo et al., 2013). An interesting result is that the male warrior hypothesis, as proposed by evolutionary psychologists (McDonald et al., 2012; Vugt et al., 2007), was not supported by the data, as male participants did not consistently outperform female participants during "us vs. them" collective action problems.

Limitations The main limitation of the meta-analytic technique, used in this chapter, is the diversity of operational definitions used in the thesis. Across all experiments I used a wide variety of methods to explore the questions of interest, which may not be directly comparable with each other. For example, the difference between Study 1 and Study 4 was not only in the type of hierarchy used (e.g. economic vs. political) but also in the sample, the types of collective action problem, and the act that one study was executed in a laboratory, while the other study was executed online as a survey. Therefore, it is always possible that the observed effect differences (in this case the difference in performance between hierarchical and egalitarian groups) can be attributed to methodological differences rather than to contrasts based on the experimental manipulations. Future research should aim to test the effects of different forms of hierarchy between experiments by keeping constant as many factors as possible.

Conclusions In summary, the meta analyses and the meta-analytic equivalence tests revealed a nuanced picture regarding many of the questions defined in this thesis. In terms of the effects of rank on player contribution, we can conclude that it may be conditional. Despite the fact that when data was aggregated between experiments in the thesis, and additional studies from other authors were included in a meta-analysis, high-rank individuals seemed to contribute more than low-rank individuals, the effect was mainly driven by the experiments employing one of two forms of economic hierarchy — based on income and based on proportional redistribution of the contest prize. Thus, we can conclude with good confidence that during at least these two forms of economic hierarchy, high-rank individuals out-perform low-rank individuals. It is still uncertainly whether players in political hierarchies acts in a similar way, due to the small number of studies involved in this thesis.

In terms of the effects of rank and benefit, both when data was aggregated between experiments, and when the type of hierarchy was taken into account, high-

rank players either earned more than low-rank players or the effect was not significant. Therefore, this finding suggests that the altruistic hypothesis may not be the case.

The effect of system type on group effort yielded uncertain results. An aggregated meta-analysis between experiments in this dissertation and studies by other authors suggests that it is not statistically significant. However, when different forms of hierarchy are subsetted, the results suggest that we have good reasons to believe that under economic hierarchy, based on income, egalitarian groups out-perform hierarchical groups, especially during "us vs. them" problems (as seen in Study 1, Study 2, and (Doğan et al., 2018)). When the type of hierarchy is based on the political operational definition used in this thesis, the result is more uncertain, as hierarchical groups usually out-performed egalitarian groups, but in some cases, such as in Study 4a, the result was conditional on other variables. When a proportional definition of economic hierarchy is used, as in experiments external to this thesis, the results were mixed.

Finally, influential hypotheses from the theoretical and empirical literature, such as the idea of parochial altruism, the differentiation between intuition and deliberation, and the effect of gender on contribution were not supported by the data and the meta-analyses strongly suggested that if there was an effect, at least in contest games, they may not be of practical relevance, if at all there. Thus, we can conclude with good confidence that, at least under the constraints of the setups employed in these experiments, the hypotheses were not supported by the data.

5

General discussion

In this chapter, I will outline my interpretation of the main results from the thesis. For each of the findings, I will discuss its connection to the previous literature and outline methodological issues. Further to that, in Section 5.2 I will point out the overarching shortcomings of the entire thesis and will outline directions for future research. Taken together, results from this doctoral project draw a rather mixed picture and contribute to a wide array of research topics within behavioural game theory and evolutionary biology.

5.1 Findings

5.1.1 Rank and individual effort

First, I found that there was a difference in player rank contribution as a function of the type of hierarchy. In economic hierarchy, high-rank players usually contributed more than low-rank players, both during "us vs. them" and during "us vs. nature" problems.

From an evolutionary and behavioural perspective, this result extends Olson's findings regarding the "exploitation of the small by the big" (Olson, 1965) to the two types of collective action problems studied in this thesis: "us vs. them" and "us vs. nature" problems. Furthermore, they support evolutionary models, which suggest that high-rank individuals will contribute more than low-rank individuals (Gavrilets & Fortunato, 2014; Gavrilets, 2015; Zhuang et al., 2012). However, the findings suggest that the effect may be bound to economic forms of hierarchy, where the incentive for contribution presented to the high-rank players is more pronounced. In political hierarchy, where there is no direct relative benefit for the high-rank individuals, the effect was not pronounced. This hints to the need of evolutionary theory to both model and test different forms of hierarchy to uncover the nuanced set of factors which influence individual effort in collective action problems.

Previous experiment with economic hierarchy have generally supported the hypothesis that high-rank players will outperform low-rank players (Fisher et al., 1995; Chan et al., 1996; Reuben & Riedl, 2009; Sheremeta, 2011; Doğan et al., 2018). Indeed, based on meta-analysis conducted in Chapter 4, the average effect size of current and previous contest games with economic hierarchy is positive, in favour of the high-rank players. Therefore, my results echo previous findings from the field. However, when talking about economic hierarchy, it is still unclear whether the results are rational considerations, social preferences for contribution of the high-rank players, or both. To overcome this problem, I aimed to verify

the results with political hierarchy as well. Political hierarchy has been previously studied in public good games. The main definition used in previous experiments was that of leadership (Van Vugt, 2006; Van Vugt et al., 2008; King et al., 2009). More specifically, leadership in collective action problem games is usually defined as the ability of one player to make the first decision in a sequential public goods game (Potters et al., 2007; Güth et al., 2007). In such games, the high-rank individuals (the leaders) contributed more (Potters et al., 2007; Güth et al., 2007; Kumru & Vesterlund, 2010; Simpson et al., 2012), which increased the contribution of the lower-rank players as well. Political rank, based on this definition of hierarchy, usually results in higher contributions. In the experiments of Study 4, however, I used a different definition of political hierarchy, based on political power, as defined by Dahl (1957). Therefore, this manipulation can be seen as novel to the literature.

One possible reason for the lack of effect for political hierarchy, except for the conclusion that high-rank individuals in political hierarchy simply do not contribute more, may be the weakness of the manipulation. In Study 4 the only difference between players of different rank was how much they may influence the group decisions. Players were not called "leaders" and were not made responsible for the well-being of the group. Thus, future research should aim to use more extreme manipulations of rank, which are based on real-world position (e.g. bosses in business organizations being the high-power players in the game) or on achievements in a previous tasks (e.g. more successful players being assigned higher power). Furthermore, even within the two forms of hierarchy used, there are potentially multiple sub-divisions. For example, political hierarchy may be based on leadership, as in many previous experiments (Potters et al., 2007; Güth et al., 2007). Economic hierarchy, on the other hand, may be based on wealth (e.g. differences in endowment for each decision) and on earning differences as a function of effort (the so called proportional redistribution (Ke, 2011)). A second shortcoming was that it is not clear what are the exact proximate mechanisms which underline this behaviour. It

is not clear why high-rank players increase their contribution in economic hierarchy and/or why low-rank players decrease their contribution. The mechanism suggested in the theoretical introduction of this thesis is evolutionary. A change of the preferences of players to exert more or less effort as a function of rank may be driven by an evolved mechanism (Gavrilets & Fortunato, 2014). However, especially during economic hierarchy, high-rank players may contribute more because they earn more from the contest or low-rank players may contribute less because they find the strategic situation unfair.

5.1.2 Rank and individual benefit

Secondly, as a function of this difference in contribution between different ranks, high-rank participants in economic hierarchy usually earned more than their low-rank groupmates. In political hierarchy, the difference was not significant in most cases, but the earnings of the high-rank players were usually less than the earnings of players in egalitarian groups. A combined meta-analysis of all experiment in the thesis demonstrated a positive effect size in favor of the high-rank players, however, this effect is mainly driven by the games with economic hierarchy.

From an evolutionary and behavioural perspective, these results suggest that high-rank players do not act seemingly "altruistically" during collective action problem games. Therefore, the altruistic bully hypothesis (Gavrilets & Fortunato, 2014), which suggests that under "us vs. them" collective action problems high-rank individuals will actually earn less than low-rank players, was not supported. In fact, high-rank players invested in the group relative to their expected earnings, and when the earnings are not connected to rank, such as in the case of political hierarchy, the investment ceased.

Previous experiments have not explicitly tackled this hypothesis in collective action problem games during "us vs. them" problems. The only evidence is from

observational research, suggesting that war leaders, both in modern armies and in hunter-gatherer groups, exhibit higher mortality rates than their peers, due to higher risk-taking at times of war (Buzzell & Preston, 2007; Glowacki & von Rueden, 2015). However, the evidence depends on multiple assumptions and is based on small sample sizes, so it should be taken with a grain of salt. Furthermore, indirect evidence for the over-contribution of high-rank players in collective action games comes from public goods games with punishment. In such experiments, when one individual was given the ability to punish other players (e.g. s/he was the high-rank player), her/his benefit from the strategic interaction was often reduced (O'Gorman et al., 2009; Baldassarri & Grossman, 2011; Diekmann & Przepiorka, 2015). However, these experiments were not studying the phenomenon during "us vs. them" collective action problems.

The lack of support for the altruistic bully hypothesis can be explained in various ways. The main explanation, however, stems from the particular mechanics of the game. As the amount of contribution and resistance is negatively correlated with the net benefit of players, a larger difference in terms of contribution and resistance will generally result in diminished earnings. Therefore, the differences in terms of contribution and resistance between high- and low-rank players in Study 1, 2, and 4 may have not been wide enough to produce reverse differences in earnings. In Study 1 and Study 2, the odds may have been particularly stacked against the support of this hypothesis, as, by definition, high-rank individuals earned more from the strategic interaction than low-rank individuals. Thus, the hypothesis may have been supported only if we have observed extreme differences in terms of average contribution. Still, in Study 4 the differences in terms of contribution and resistance between high-power and egalitarian players have been consistently high, and there were no differences in terms of income, thus the expected net benefits have diminished. Future research should aim to use more extreme manipulations, which do not lead to discrepancies in terms of income or endowment, and which may

lead to higher difference in terms of contribution between different player ranks.

5.1.3 System type and group effort

Results from this thesis suggest that politically hierarchical groups were more likely to outperform egalitarian groups in most cases (however, this over-contribution was conditional on the time constraint variable in Study 4a). In economic hierarchy, this result was usually reversed, as participants in egalitarian groups were more likely to outperform participants in hierarchical groups in terms of group contribution during "us vs. them" and "us vs. nature" problems.

These findings suggest that the type of hierarchy may be an important factor which determines group performance during various types of collective action problems. The expectation that hierarchical groups will outperform egalitarian groups (Gavrilets & Fortunato, 2014; Gavrilets, 2015; Zhuang et al., 2012) was supported mostly with political hierarchy, while the reverse result was usually observed in experiments with economic hierarchy.

As discussed, results from both public goods games and contest games regarding this hypothesis are rather mixed. In public goods games, some research groups demonstrated that egalitarian groups outperform hierarchical groups (Chan et al., 1996; Reuben & Riedl, 2009), while other research groups have observed the opposite results (Bagnoli & McKee, 1991; Rapoport & Suleiman, 1993). There have been also a number of studies which do not find a statistically significant difference between the two system types (Marwell & Ames, 1979; Van Dijk & Grodzka, 1992). In contest games, some researchers have found an increase in contribution by hierarchical groups (Gunnthorsdottir & Rapoport, 2006; Kugler et al., 2010), while others found an increase in contribution by egalitarian groups (Ke, 2011).

Furthermore, in a meta-analysis including all previous contest game experiments, together with the experiments presented in this thesis (see Chapter 4), I have shown

that the average meta-analytic effect size is not significant. All of the external studies, however, were based on economic hierarchy. In all experiments, high-rank participants in hierarchical groups either earned more (e.g. income differences) or had a larger endowment (e.g. wealth differences). Based on my knowledge, the experiments presented in Study 4 are the first to use a definition of hierarchy based on political power in contest games.

Interestingly, as seen in Chapter 4, lower performance by groups with economic hierarchy may be driven mainly by reduced effort of low-rank players. These diminished contributions of low-rank players in economic hierarchy have been observed in other experimental studies as well (Cronin, Acheson, Hernández, & Sánchez, 2015; Doğan et al., 2018). One possibility for this result may be specific proximate mechanisms, such as fairness and/or economic inequality aversion. Indeed, previous experiments have shown that humans have proximate preferences for fairness. In economic games, such as the ultimatum game, participants often preferred an equal split and were unhappy when others did not prefer the same (Oosterbeek et al., 2004). The fairness phenomenon has been observed in other experimental games with human participants (Fehr & Schmidt, 1999, 2000, 2010) and with non-human primates (Brosnan & De Waal, 2003; Brosnan, Schiff, & De Waal, 2005; Brosnan, 2009; Leimgruber, Rosati, & Santos, 2015). Fairness has been seen a central explanatory force for how human morality works, both in economic (Rabin, 1993) and evolutionary theory (Curry, 2016). Fairness is closely related to economic inequality aversion, often studied in the economic literature. Indeed, in previous studies, when participants were given randomly wealth, they were likely to pay to restore the balance, by reducing wealth of wealthier individuals and by increasing the wealth of the poor individuals (C. T. Dawes et al., 2007; Blake et al., 2015). Thus, human fairness or inequality aversion preferences may be driving the diminished contribution of low-rank players in comparison to high-rank players and players in egalitarian groups. Indeed some evidence from this

set of experimental studies makes exactly this suggestion. In Study 3a, when the high-power players in the group were given a bonus on top of their baseline earnings, which can be interpreted as a simulation of economic inequality, in some cases the low-rank players contributed less and were more resistance. A second possible mechanism may be the rational considerations of lower-rank players. In most theoretical models of hierarchy, low-rank players in hierarchical groups are expected to free-ride (Olson, 1965; Gavrilets & Fortunato, 2014; Gavrilets, 2015, 2014). Therefore, it is possible that the diminished contribution of low-rank players is due to rational considerations, as their predicted contribution is lower than the predicted contribution of high-rank players.

The differences between economic and political hierarchy in these experiments hint at two further conclusions. First, the finding suggests again that economic models of hierarchy may not be sufficient to explain the vast array of operational definitions of within-group heterogeneity. Hierarchy may indeed help groups solve the collective action problems at hand, together with additional mechanisms, such as true altruism, reciprocity, reputation, internalized social norms, and third-party punishment (McElreath & Boyd, 2007; Nowak, 2006; Richerson & Boyd, 2005; Bowles & Gintis, 2011). However, they may have the potential to be detrimental to the group's performance, especially when defined in economic terms. Second, in the real world, hierarchies are not strictly one dimensional. Political hierarchies go hand in hand with economic hierarchies and prestige-based hierarchies. Thus, the interaction between different forms of hierarchies may be a fruitful area for future research. For instance, in Experiment 3a, participants changed their resistance preference toward the high-power individual in their group only when s/he was to receive more from the prize, which simulates a form of economic hierarchy on top of political hierarchy. Furthermore, future research should aim to diversify the number and types of hierarchies under study and to explore the exact proximate mechanisms which drive the reduced contribution of low-rank players. Various

types of hierarchies, which are not based on monetary incentives, should be used, as this will allow researchers to disentangle the phenomenon of fairness and inequality aversion from the contribution preference biases of players.

5.1.4 Collective action problems and individual effort

The type of collective action problem faced by the group may not be as important for the contribution preferences of players as originally predicted in the literature (Choi & Bowles, 2007; Bowles, 2009). Across all experiments, only one variable produced a consistently significant increase in contribution. Namely, when participants were playing under group penalty, which can be seen as a rank-order tournament, their contribution increased. However, when participants played inter-group vs. control contests, e.g. when the salience of the other group was manipulated, the average effect size across all experiments approached zero and can be significantly defined as too small to be of practical relevance. Finally, the difference between in-group vs. out-group contests did not change significantly the contribution of players.

These results suggest that, at least in contest games, only incentive-based definitions of "us vs. them" collective action problems produce a meaningful effect on the contribution of players, probably due to threshold, rational considerations, and/or loss aversion effects. This goes against theories from social psychology (Tajfel, 1982; Brewer, 1999; Hewstone et al., 2002) and evolutionary biology (Choi & Bowles, 2007; Bowles, 2009) which suggest increase in contribution in such cases.

It is important to note that in this thesis we cannot make strong inferences about how participants react toward "us vs. nature" collective action problems, as these problems have been used as control conditions in all of the experiments. We can only see whether there is a difference in the reaction, or the cognitive biases involved, when the collective action problem changes. With the group penalty manipulation, "us vs. them" collective action problems (e.g. contests with penalty)

led to more contributions than "us vs. nature" collective action problems (e.g. contests without penalty). However, this may be due to a confounding effects, stemming from incentive maximization. The results from the comparison between inter-group and control contests, however, are not driven by incentive-maximization considerations, as in such cases the only difference between the two conditions was whether the out-group was salient or not. In such cases, as show in the meta-analysis in Chapter 4, the results did not support the hypothesis, suggesting no difference between the two conditions. Thus, we can only say that the hypothesis is not supported, and that the results may suggest that, if there is a difference between the two collective action problem types, it may be really small.

Previous meta-analyses (Balliet et al., 2014; Bauer et al., 2016), as well as individual studies (Bauer et al., 2017; Gilligan et al., 2014; Voors et al., 2012; Hewstone et al., 2002; Everett, Faber, & Crockett, 2015; Puurtinen & Mappes, 2009), have suggested that indeed participants are more likely to contribute more toward the collective action problem at hand when an out-group is salient. The results in this thesis do not support in a straightforward manner these findings.

The lack of meaningful effect size of the contest type manipulation (inter-group vs. control) has novel consequences for the interpretation of contest games in behavioural game theory. Contest games are usually equivalent to the inter-group contests used in this project, where two or more groups compete against each other for a fixed prize and the group with higher group effort has a higher chance to win the prize. The defining characteristics of these games are: (i) the fact that they emulate "us vs. them" collective action problems, and (ii) the fact that the prize is probabilistic and conditional on the group effort. In the public goods game paradigm, this is not always the case, as in most experiments the aim of groups is to produce a public good (not to win a competition) and the payoffs of the players are directly connected (and not probabilistically) to the group's total contribution, which is usually multiplied and redistributed. The lack of meaningful

difference between inter-group and control contests suggests that the nature of contest games as a simulation of "us vs. them" collective action problems may not be the most important characteristic of this paradigm, as both in "us vs. them" and in "us vs. nature" collective action problems participants exhibited similar levels of contribution. What may be more important in these games is the second characteristic: the probabilistic relationship between contribution and benefit.

The significant effect of group penalty can be explained in multiple ways. One possible explanation is that it is indeed a reflection of humans' evolved tendencies to contribute more during inter-group competition in comparison to cases when such competition does not exist. Indeed, previous experimental studies have reached similar conclusions. In one experimental study Bornstein, Gneezy, and Nagel (2002) contrasted two types of competition with a no competition condition. Competition between groups was for a prize, similarly to the way the group penalty has been operationalized in Study 1 and Study 2. In one case participants in pairs of groups played against each other where the group with lower minimum contribution in the pair did not earn any benefit from the game. In the other case, the winning group earned a bonus on top of their baseline earnings. Both definitions of competition increased the group performance in comparison to cases with no competition. This result has been replicated in experiments under varying manipulations of competition (Puurtinen & Mappes, 2009; Burton-Chellew et al., 2010; Cárdenas & Mantilla, 2015). However, some authors have argued that competition between groups, such as the group penalty variable in Study 1 and Study 2, creates natural threshold effects. An individual is not influenced by the competition itself but by her/his desire to reach the threshold (e.g. to contribute more than the opponent). Indeed, in a set of experimental studies Jordan, Jordan, and Rand (2017) demonstrated that the increase in contribution of group members is due to their aim to reach the desired goal, which allows them to win the competition (or not be penalized in the case of the presented experiments). Other authors, however, have pointed out that

such threshold effects are an inherent feature of all types of competition, thus it is impossible to disentangle their influence from the influence of competition itself (Majolo & Romero, 2018). Still, it remains the case that this type of manipulation can be potentially explained by many other proximate mechanisms, which can fall broadly into the cognitive biases category. One potential explanation is the so-called loss aversion bias, which refers to people's propensity to priorities avoiding losses over making gains. In other words, for humans "losses loom larger than gains" (Kahneman & Tversky, 1979; Tversky & Kahneman, 1991). This behaviour has distinct neural correlates (Tom, Fox, Trepel, & Poldrack, 2007) and has been observed in non-human species as well (M. K. Chen, Lakshminarayanan, & Santos, 2006). The way the group penalty variable was operationalized in Study 1 and Study 2 is highly susceptible to the loss aversion bias, as participants were not playing to win more but were playing to loss less. Therefore, one possible interpretation is that participants' increased contribution is a function of their unwilling to lose their earnings from the round. Future research should aim to explore the effects of competition without explicit monetary incentives. For instance, in an influential study within evolutionary biology Burton-Chellew and West (2012) demonstrated that just ranking groups based on their performance, without awarding them extra resources for higher rank (or substracting resources for lower rank), was enough to activate the contribution bias of players (e.g. players contributed more when there was ranking in comparison to a condition without ranking). This result has been replicated in other experimental studies as well (Böhm & Rockenbach, 2013; Tan & Bolle, 2007). The use of this manipulation, called pseudo-competition, may allow researchers to exclude the possibility that the contribution bias is driven predominantly by monetary incentives, loss aversion biases, and/or threshold effects.

5.1.5 Collective action problems and resistance

The type of collective action problem did not affect the resistance preferences of players as well. Unexpectedly, when participants played in-group vs. out-group contests, or inter-group vs. control contest, their resistance toward the leader or the group decision did not change.

There are many potential reasons for this results. One reason may be that this research hypothesis indeed may not be the case — e.g. humans may not have conditional preferences for resistance as a function of the type of collective action problem faced by their group. Indeed, all participants sacrificed a relatively high percentage of their earnings from the experimental game (ranging from 29.61% in Study 3b to 40.52% in Study 4a), but this did not change as a function of the problem type.

Previous experimental studies have only hinted a conditional nature of our preferences toward hierarchy. Indeed, a set of experiments in social psychology researches have shown that groups are more likely to select leaders when their group is unable to solve the collective action problem at hand (Rutte & Wilke, 1984; Samuelson et al., 1984; De Cremer & Van Vugt, 1999). Facial perception studies have further demonstrated that our preferences toward leadership change as a function of the problem faced by the group (Little, Burriss, Jones, & Roberts, 2007; Spisak, Dekker, Krüger, & Van Vugt, 2012). Finally, political science studies suggested that the approval rating of politicians currently in charge (such as U.S. presidents) increases after an event which signals inter-group conflict or competition, such as the Cuban missile crisis (J. R. Lee, 1977; Chapman & Reiter, 2004). The experiments in this doctoral thesis were unable to extend the findings from all previous behavioural and political science studies and to support the research hypothesis.

Further research should aim to check the validity of this hypothesis under different forms of "us vs. them" collective action and different forms of resistance

definitions. For example, the "unrealistic" setting in which participants were placed may not be enough to trigger their innate preferences for conditional resistance, if such preferences exist. Using a more severe manipulation (for instance two groups competing against each other in live settings) may be more appropriate. Furthermore, the operational definition of resistance used in this game has inherent drawbacks. In many of the experimental studies participants did not receive direct feedback about the performance of their group during the game. Previous research has shown that participants are more likely to be supportive toward hierarchy once their group has been shown to be failing the collective action problem at hand (Rutte & Wilke, 1984; Samuelson & Messick, 1995; De Cremer & Van Vugt, 1999). It may be indeed the case that the degree of group failure may mediate the resistance preferences of players, dependent on the collective action problem.

5.1.6 Gender and individual effort

In terms of exploratory questions, meta comparisons revealed that gender (male vs. female) did not influence the contribution preferences of players. Even during "us vs. them" collective action problems, the gender variable did not affect the contribution preferences of players conclusively in one direction or another.

Regarding gender, the findings are not in line with previous studies which suggest that female participants may be more altruistic than male participants in economic games and to theoretical views that male participants are more cooperative than female participants during "us vs. them" collective action problems (Vugt et al., 2007; McDonald et al., 2012).

Indeed, in game theory experiments, females tend to give more to the other player, which indicates their willingness to sacrifice personal gain for the good of others. For example, in a meta-analysis on several Mechanical Turk experiments, including more than 3500 participants, Brañas-Garza et al. (2018) showed that in

a simple Dictator's Game female participants were willing to give more of their personal endowment to increase the endowment of the other player, compared to male participants. This result replicated previous findings from the experimental literature of economic games (see Andreoni and Vesterlund (2001) and Dreber et al. (2014) for examples). Even within games which study collective action explicitly, such as the public good game, some experiments demonstrated increased contribution of female players (Aranoff & Tedeschi, 1968; Meux, 1973; Nowell & Tinkler, 1994), while in other studies male participants contributed significantly more than females (Rapoport & Chammah, 1965; Brown-Kruse & Hummels, 1993). My results suggest that the gender differences are either too small or non-existent, based on a meta-analytic equivalence test. Indeed, in a large-scale meta analysis, consisting of more than 272 experimental studies, Balliet et al. (2011) found that the type of social dilemma actually matters. Across all experiments, the authors found than in the prisoner's dilemma game female participants contributed slightly more than male participants, while in resource dilemmas the results were reversed, as male players contributed more. In the public goods games the average effect size (d) was 0.1, thus the gender variable was not influential, similarly to what was observed in this thesis. Thus, results in this thesis contribute to the general conclusion that gender does not affect contribution in collective action problems games. Furthermore, the result do not replicate previous theoretical suggestions and empirical findings which show an interaction between gender and the type of collective action problem at hand (Vugt et al., 2007; McDonald et al., 2012; Balliet et al., 2014), the so called male warrior hypothesis.

These results, however, are limited to the specific samples used in this experiments. Furthermore, in many of the experimental studies the number of male and female participants was not perfectly balanced. Further research should aim to use more diverse and balanced samples, which will increase the chance of detecting a meaningful effect of the gender variable, if such effect exists.

5.1.7 Cognitive processing and individual effort

Finally, the time constraint variable (time pressure vs. time delay) did not produce a meaningful effect sizes across studies.

Interestingly, based on my knowledge, this research question has not been explored previously in the contest game paradigm. Previous studies have explored a vast range of experimental games, such as the public goods game, the prisoner's dilemma, the ultimatum game, and the trust game, and have shown a positive effect size in favor of the time pressure condition (Rand, 2016).

The contest game differs from these experiment by introducing a probabilistic component and an "us vs. them" element. Future research should study the effect of processing speed by using different experimental manipulations. For example, other researchers have gone beyond the standard time pressure vs. time delay manipulation by implementing a cognitive load manipulation. In cognitive load experiments, researchers ask participants to solve a mental task of varying difficulty (for instance to substract digits in memory) (Døssing, Piovesan, Wengström, et al., 2017). The assignment of a more complex mental task is expected to induce a more intuitive response. A second type of manipulation is just to ask participants to give their intuitive response without constraining the time for each decision (Liu & Hao, 2011). Future research should also aim to test this question with a between-subject, rather than a within-subject experimental design, which has been used in all experiments so far.

5.2 General shortcomings and future research

This research project has some overarching shortcomings, which are applicable to most experiments in this thesis and in some cases to the field of experimental research in general. These include issues with the specific sample, the ecological validity of the studies, and the limited number of hierarchies under study.

5.2.1 Sample and validity

Firstly, the sample of participants is always a challenge in empirical research. Researchers have argued that most experiments have been done with samples of Western, educated, and industrialised participants, which are mainly university students participating for course credit (Henrich, Heine, & Norenzayan, 2010). In this project I have used participants recruited from three different national groups. In Study 1 and Experiment 4a all participants were residents of the United Kingdom, while in Study 2 and Study 3 all participants were residents of the United States. In Experiment 4b participants were ethnic Bulgarians. The sample included participants of various ages, but most players can be still classified as representatives of Western cultures. Thus, one potential shortcoming of the research was the lack of sufficient cultural variability in the studied samples. Further research should aim to generalize the findings to non-Western cultural groups.

Secondly, the controlled experimental nature of the studies was a potential limiting factor for the generalizability of the results. Controlled experiments allow researchers to isolate potential confounding factors by making them either randomly distributed between conditions or by making the appropriate measurements combined with statistical techniques. Thus, causality may be inferred with a higher degree of certainty. Furthermore, the goal of behavioural game theory experiments is to isolate the essence of a specific strategic interaction, in this case of the mismatch between individual and collective interest, which crystallizes in the

collective action problem. However, in all experiments participants were making their decisions in artificial settings, which may be considered sufficiently different from the naturalistic contexts in which they are making their day-to-day decisions. Further research should aim to cross-reference the findings of this set of studies with more realistic settings, where real groups perform collective action problem tasks (such as constructing a building), while players of different ranks are observed.

5.2.2 Forms of hierarchy and proximate mechanisms

As previously discussed in Chapter 1, I defined hierarchy as a difference of rank based on a valuable social dimension (Magee & Galinsky, 2008). In this thesis I explored only two types of hierarchy — based on either economic resources or political position. Thus, all findings are bounded to one of these two definitions of hierarchy. As seen across experiments, the specific type of hierarchy is an influential factor for the contribution preferences of players.

For instance, economic hierarchy can be confounded with rational choice considerations, e.g. participants of higher rank may contribute more than participants of lower rank because of their willingness to maximize their personal income, not because of evolved psychological mechanisms which drive their behaviour. This result may be even stronger under different definitions of economic hierarchy, such as the one based on proportional redistribution of resources relative to the exerted effort, used in many previous experiments (Buckley & Croson, 2006; Brookins et al., 2015; Ke, 2011), where the amount of monetary units invested does not only increase the probability of the player's group winning the prize but also increases his/her direct earnings if the prize is won. It is hard to overcome this problem with economic hierarchies, as, by definition, they are always correlated with discrepancies in the net income. Further to the purely rational considerations, as discussed in Section 5.1, for economic forms of hierarchy there are many additional proximate mechanisms

at play, which can be seen as confounding factors, such as inequality aversion, loss aversion, threshold effects, and fairness considerations. These mechanisms are usually triggered by willingness of the players to maximize absolute or relative personal gain. For instance, the loss aversion mechanism is a psychological bias which has to do with the willingness of participants to sacrifice winnings to minimize monetary losses, and has been mainly studied in economic games (Kahneman & Tversky, 1979; Tversky & Kahneman, 1991). The issue of fairness considerations and inequality aversion has to do with minimizing the difference in terms of income or wealth between the focal individual and all other players involved in the strategic interaction (Blake et al., 2015; C. T. Dawes et al., 2007; Fehr & Schmidt, 1999, 2000, 2010). Therefore, these mechanisms can be seen as bounded to economic forms of hierarchy, for instance based on wealth or income. One potential technique to overcome the problem may be to use already existing forms of natural economic hierarchy. For example, researchers may recruit participants with various economic statuses from real social groups and match them in groups of "richer" and "poorer" players, by making explicit their economic standing. However, this may introduce additional confounding factors in the study, such as cultural hatered toward the rich, based on historical class struggles in the selected society.

A second potential technique, as employed in this thesis, is the use a political form hierarchy based on power. In this form of hierarchy, proximate mechanisms, such as rational and fairness considerations, loss aversion effects, and inequality aversion, are not directly applicable, as high-rank individuals do not receive higher economic incentives than low-rank individuals. However, it is important to acknowledge that other forms of political hierarchy may yield different results. For instance, other experiments have employed a definition of leadership, where high-rank individuals are more likely to act first in a public goods game (Kumru & Vesterlund, 2010; Simpson et al., 2012; Potters et al., 2007; Güth et al., 2007). However, in these experiments, as the move of the first player is public, the increased contribution

may be driven by private considerations, such as shame or willingness to look good in front of the group. Thus, a definition of political hierarchy based on power may be a better solution to study the effects without additional confounding variables. However, this definition may be considered too weak, as players are assigned randomly to be of high- or low-rank. One possible way to overcome this shortcoming is to use more realistic definitions of political rank, such as definitions based on real-world political standing, where the high-rank players in the game are actually the high-rank individuals in the selected society. However, as with the "realistic" manipulation of economic hierarchy, this may confound cultural factors, such as between-class hatred.

In sum, as seen, all possible definitions of hierarchy have pros and cons. While the results in the experiments with economic hierarchy are less certain, as such experiments are susceptible to more proximate biases, driven by self-interest, results from political hierarchy may be more indicative of the human predisposition toward hierarchy. As outlined, alternative definitions of both political and economic hierarchy may have led to novel confounding factors, such as issues with societal status (willingness to look good in front of the group) or historic cultural dynamic in the selected social group. It is important to note, however, that these remarks do not apply to some of the research hypotheses in this thesis. For instance, the effects of the collective action problem type, gender, and time constrain on contribution are not biased by such proximate mechanisms. Only the effect of the group penalty conditions may be driven by the loss aversion bias, as discussed previously. While the scope of this research project did not allow me to draw conclusions about the precise rationale behind some of the findings, I think that future studies should be executed with various definitions of political and economic hierarchy, which will help scientist study the nuances of the interaction between collective action problems and hierarchy. A critical mass of experiments which study varying definitions of these forms of hierarchy will allow research to "extract" the common pattern

and illuminate with more certainty the innate predispositions of humans toward rank inequality. Furthermore, additional forms of hierarchy, for instance based on prestige or achievement, may yield different results, which may be a fruitful area of future research and the only way to disentangle proximate from evolutionary motives in the contribution preferences of individuals.

5.3 Final remarks

In sum, this thesis presented data from eight experimental studies, covering more than 2300 participants from three national culture. The project uncovered some of the effects of hierarchy and "us vs. them" collective action problems on human contribution and resistance preferences, and the corresponding benefits to individuals. More specifically, as initially stated, during collective action problems humans exhibit mismatch between the need to help the group and the desire for individual gain. This problem has been coined a central issue in evolutionary theory, for which many theoretical mechanisms have been proposed, including altruism, reciprocity, reputation, internalized social norms, and third-party punishment (McElreath & Boyd, 2007; Nowak, 2006; Richerson & Boyd, 2005; Bowles & Gintis, 2011). The proposition that hierarchy may provide an additional mechanisms which helps groups solve collective action problems has received mixed support in this thesis. The contribution preferences of players were likely dependent on the type of hierarchy participants were placed in. In groups with economic hierarchy, high-rank players exerted more effort than low-rank players, but this did not produce an increased performance of this system type in comparison to economic egalitarianism, as low-rank players were underperforming severely. In political hierarchy, the difference in terms of contribution between different ranks of players was not as important, but hierarchical groups exerted more effort than egalitarian groups in most cases. Manipulations of the type of collective action problem were rarely influential, as usually they did not change the differences in contribution exhibited by different ranks of players and the average contribution and resistance of groups. Only group penalty, which can be seen as a type of incentive-based tournament, was influential. Finally, neither gender, nor time constraint produced consistent effects across studies. As this was the first direct manipulation of time constraint in contest games, this represents a novel addition to the vast literature on dual processing

manipulations. Moreover, the male warrior hypothesis, as predicted by evolutionary scientists, has not been supported by this thesis. Future research should generally aim to test the effects under different definitions of hierarchy, different definitions of conflict, and with diverse cultural groups. Furthermore, any upcoming experimental studies should aim to untangle the proximate cognitive mechanisms underlying the observed conditional changes in preferences.

Appendices

A

Study 1

A.1 Methods

Both experiments in Study 1 followed a similar experimental procedure. Participants were invited to the laboratory into batches of 16 players.

Procedure Participants in both studies read information sheets, signed consent forms, and were assigned a booth to play the game from. Participants went through instructions regarding the experiment and played a training session to familiarize themselves with the experimental software used to run the game. All participants in both studies played a number of contest games in groups of four.

Manipulations The difference between Experiment 1a and Experiment 1b was how the prize was distributed between players if their group won the contest. In

Experiment 1a all groups were hierarchical. Thus, if a group won the prize in the contest, its members received a share, either 40%, 30%, 20% or 10% of the prize. In Experiment 1b all groups were egalitarian, thus all players in each group received an equal share of the prize.

Across both experiments, I manipulated three independent variables. First, I manipulated the contest type played by participants. In some cases participants played inter-group contests. In such contests all 16 players currently in the game were split into four groups of four players. Each group played a two-group contest with all other groups. In other cases, participants played control contests, where instead of being matched with another group to play for a prize, participants played as a group against no opponent. Second, after some contest games, all groups in the experimental session were arranged in a descending order based on their total contribution. Members of the group with the lowest total contribution were assigned a probability of losing all their earnings. Members of all remaining groups did not receive any chance of losing all their earnings. Finally, in some cases participants were asked to make some of their decisions under time pressure, which was indicative of their intuitive contribution preferences.

Payments All participants in Experiment 1a and Experiment 1b were paid a show-up fee of £4. Within the game, all participants earned monetary units, a fictional currency used only in the experimental setup. Fictional currencies have been used in other experimental economics studies (see Abbink et al. (2010) for an example). Before the beginning of the experiment all participants were told the exchange rate for converting monetary units to British pounds (£). The exchange rate for Experiment 1a was 1 monetary unit = £0.0017, while the exchange rate for Experiment 1b was 1 monetary unit = £0.00221. The differences between the exchange rates were due to the differences between the endowments and the number of decisions a participant has to make. Participants in Experiment 1a were paid

bonuses of £8 on average, while participants in Experiment 1b were paid bonuses of £4 on average. All bonuses were based on their earnings during the experiment.

Ethics Experiment 1a and Experiment 1b were approved by Departmental Research Ethics Committee, School of Anthropology and Museum Ethnography, University of Oxford; Nuffield Centre for Experimental Social Science, University of Oxford; Institutional Review Board, University of Tennessee, Knoxville; U.S. Army Research Office; and Oxford Tropical Research Ethics Committee.

Group-level comparison To test the hypothesis whether hierarchical groups will outperform egalitarian groups during "us vs. them" collective action problems, I aggregated group-level data from Experiment 1a and Experiment 1b. For each randomly assigned group in both experiments, I calculated its total contribution (X_i) relative to its total endowment (E_i). The quotient from $\frac{X_i}{E_i}$ is the group's total contribution as a percentage of its endowment, which I used as a dependent variable on a set of group-level comparisons.

A.2 Analytical framework

Linear mixed effects models To analyze the results, in both experiments I employed a linear mixed effects (LME) modeling framework. This technique allows for unbalanced designs in terms of sample size differences between conditions (McCulloch & Neuhaus, 2001) and emphasises variance over point estimates (Gelman & Hill, 2006). The goal of the LME model is to take into account the non-independence of the explanatory factors due to overarching clustering structure, such as a player or a group (Gelman & Hill, 2006). In the case of these experimental study, the models take into account whether the fixed effects of specific independent factors are influenced by random effect idiosyncrasies of participants, such as a difference between participants in terms of effect size and direction produced by a specific manipulation.

Random structure specification For all LME models, I aimed to start with the maximal random effects justified by the experimental design. The maximal random structure includes all random intercepts and slopes for all independent variables and their corresponding interactions which are nested in the grouping variable, together with all correlations among the random effects (slopes and intercepts). This approach has been supported by previous statistical research (Barr et al., 2013). Usually, in psychological experimental designs, the use of the maximal random structure is not always feasible due to (i) a smaller number of observations than a number of estimated random effects for the random term or (ii) problems with the optimization algorithms (Singmann & Kellen, 2017). Thus, for all models I reduced the maximal random structure by either removing the correlations among the random intercepts and slopes, as the correlations are the biggest contributor to the increase of the number of estimated random effects parameters, or by removing the interactions between the random-effects variables. This strategy has been suggested by previous

research (Singmann & Kellen, 2017) and allows for the reduction of the number of estimated parameters to a manageable size for the statistical software. Moreover, the strategy is supported by simulations which show weakening of the model's power with maximal random structure and insufficient data (Matuschek et al., 2017). Thus, by reducing "weak" components from the random structure one trades an increased power for slightly higher Type I error rate (Matuschek et al., 2017).

Contrasts comparisons I conducted various contrast comparisons to (i) test all pre-defined hypotheses and to (ii) further explore any statistically significant interactions. Such analyses were done with the estimated marginal means (EMM), based on the fitted LME model. This measurement tells us the mean estimated response for a variable, given all other variables in the specified model (R. Lenth, 2017). In other words, the estimated marginal means are not the means from the data but are based on the model's predictions, which "guards" the inferences from overfitting (Gelman & Hill, 2006). Unless stated otherwise, I used the Tukey multiple comparisons adjustment (Tukey, 1949) for all EMM contrasts.

Implementation and presentation The baseline LME models were fitted with the R package "afex" (Singmann et al., 2016). The EMM comparisons were done with the "emmeans" package (R. Lenth, 2017). The results from each model will be presented as an ANOVA table with approximated p-values which were calculated with the Kenward-Roger approximations for degrees of freedom (Kenward & Roger, 1997).

A.3 Materials for Experiment 1a

A.3.1 Instructions

Instruction 1: About the study

> Welcome!
>
> You are about to take part in a decision-making experiment.

Instruction 2: Earnings

> You will be paid in private and in cash at the end of the experiment.
>
> The amount you will receive depends on your decisions, so please follow the instructions carefully.
>
> During the experiment you will have the chance to earn monetary units, which will be converted into cash at the end of today's session.
>
> The exchange rate is 1 monetary unit = £0.0017.

Instruction 3: Sessions and rounds

> **Inter-group contests** The study includes 16 sessions, each including 3 rounds.
>
> In each round, your group will compete against another group in a contest game for a prize.
>
> There are four groups playing at any one time.

> **Control contests** The study includes 16 sessions, each including 3 rounds.
>
> In each round, your group will play a game for a prize.
>
> There are four groups playing at any one time.

Instruction 4: Group formation

> At the beginning of each session you will be randomly matched with 3 other participants to form a group of 4.
>
> Each participant in this room will be a member of one group.
>
> After the end of each session you will be randomly matched again with 3 players

to form a new group.

Instruction 5: Anonymity

The experiment is completely anonymous.

The participants' identity will not be revealed, neither during nor after today's study.

You will not know who your group mates are, and they will not know who you are.

Instruction 6: Your options

Inter-group contests You will begin each round with a "pot" of 120 monetary units.

You can contribute any amount from this pot to your group's success in a contest against another group.

Any amount you decide to keep will be added to your total earnings from the round.

Your group mates and members of the other group will have the option to contribute to the contest in the same way as you do.

Control contests You will begin each round with a "pot" of 120 monetary units.

You can contribute any amount from this pot to your group's success in the game.

Any amount you decide to keep will be added to your total earnings from the round.

Your group mates will have the option to contribute to the game in the same way as you do.

Instruction 7: The prize

Inter-group contests In each round your group will be in a contest with another group for a prize of 300 monetary units.

At the end of each round, the chance to win this prize is determined by the total contributions by members of your group, compared to the total contributions

by members of the other group.

Example: If your group contributed 60 monetary units overall, while the other group contributed 40, your group will have a 60% chance of winning the prize, while the other group will have a 40% chance.

Control contests In each round your group will play a game for a prize of 300 monetary units.

At the end of each round, the chance to win this prize is determined by the total contributions by members of your group. The more monetary units your group contributes, the more likely it will win the prize.

Example: If your group contributed 60 monetary units overall, your group will have a higher chance of winning the prize, compared to a situation when it contributed 40 monetary units.

Instruction 8: Earnings

If your group wins the contest, the prize will be divided unequally among group members in different shares.

One group member will receive 40% of the prize, one 30%, one 20%, and one 10%.

Your expected share of the prize is decided randomly and changes between sessions.

At the beginning of each session, you will find information about the share you will receive. This information will be on your screen while you make your decision.

Instruction 9: Sessions with group penalty

Remember, each session includes 3 rounds.

Some sessions are group penalty sessions.

At the end of these sessions, your group's total contribution will be compared to those of the other 3 groups.

The group with the smallest total contribution has a 50% chance of being penalized.

> If your group is penalized, you lose all your earnings from the session. This includes:
>
> 1. any "leftovers" (i.e. any amounts from your pots you did not contribute), across the 3 rounds;
> 2. any shares of the prize you received, across the 3 rounds.

Instruction 10: Sessions without group penalty

> Other sessions are not group penalty sessions.
>
> At the end of these sessions, groups will not be penalized.
> At the beginning of each session, you will find information about whether the session is a group penalty session.

Instruction 11: Sessions with time constraint

> Some sessions are time constraint sessions.
>
> In these sessions, in each round you have 6 seconds to make your decision.
> If you do not make your decision within 6 seconds, the computer will randomly "decide" your contribution for the round.

Instruction 12: Sessions without time constraint

> Other sessions are not time constraint sessions.
>
> In these sessions, in each round you have unlimited time to make your decision.
> At the beginning of each session, you will find information about whether the session is a time constraint session. This information will be on your screen while you make your decision.

A.3.2 Quiz

After the end of all instructions, participants went through a quiz about the game. Both the quiz and the answers were read by the experimenter. The emboldened answers are the correct answers.

Quiz instructions

Now we will ask you questions about the rules of the game.

Please ask the experimenter if you have any further questions.

Question 1

Inter-group contests What determines your chance of winning the contest?

1. **Your group's contributions and the contributions of the other group.**
2. Mainly your group's contributions.
3. It is randomly determined.

Answer: The correct answer is 1). The probability of winning the prize is determined by the total contribution of the members of your group during the round and that of the members of the other group.
For example, if your group contributed 30 monetary units overall, while the other group contributed 70, your group will have a 30% chance of winning the prize, while the other group will have a 70% chance.

Control contests What determines your chance of winning the prize?

1. Your group's contributions and the contributions of the other groups.
2. **Mainly your group's total contribution.**
3. It is randomly determined.

Answer: The correct answer is 2). The probability of winning the prize is mainly determined by the total contributions of the members of your group during the round.
For example, if your group contributed 30 monetary units overall, your group

> will have a smaller chance of winning the prize, compared to a situation when it contributed 70 monetary units.

Question 2

> In one round, you contributed 50 of your 120 monetary units, and your group wins the prize of 300 monetary units. You receive 40% of the prize. What are your total earnings for this round?
>
> 1. **190**
> 2. 50
> 3. 120

> Answer: The correct answer is 1). You have 70 monetary units leftover from your pot $(120 - 50)$ and you receive 120 monetary units from the prize (40% of 300).

Question 3

> In a group penalty session, what happens at the end of the session if your group has the smallest total group contribution compared to the other groups?
>
> 1. Your group will be certainly penalized.
> 2. **Your group has a 50% chance of being penalized.**
> 3. Nothing will happen.

> Answer: The correct answer is 2). In group penalty sessions, the group with the smallest total contribution has a 50% chance of being penalized. If your group is penalized, you lose all your earnings from the session.

Question 4

> In a session with time constraint, how many seconds do you have to make your decision?
>
> 1. 15 seconds
> 2. 120 seconds
> 3. **6 seconds**

> Answer: The correct answer is 3). With time constraint, you have 6 seconds to make your decision.
> Please, ask the experimenter if you have any additional questions!
> Now you will play one training session of 3 rounds.

A.3.3 Training round

Each group of participants played a training period of 3 rounds. It had the same structure as a typical period from the actual experiment (see below). In all round, all participants received an equal share of the prize.

A.3.4 Period information view

Before the beginning of each period, participant saw an information view (see a sample in Figure A.1).

The text depended on the group penalty condition:

> **Group penalty**
>
> The following session is a GROUP PENALTY session. At the end of the session, the groups' total contributions over the 3 rounds will be compared. The group with the smallest total contribution will have a 50% chance of losing all its earnings from the session

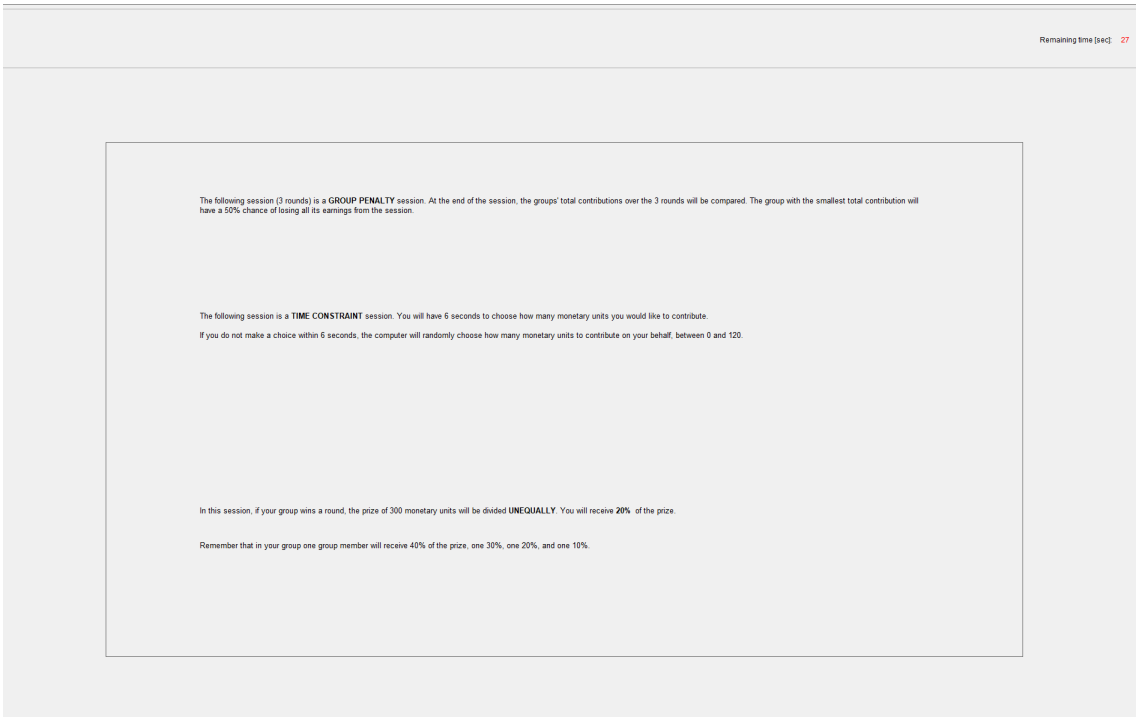


Figure A.1: Period information view in Experiment 1a

> **No group penalty**
>
> The following session is NOT a GROUP PENALTY session.

The text depended on the time pressure condition:

> **Time pressure**
>
> The following session is a TIME CONSTRAINT session. You will have 6 seconds to choose how many monetary units you would like to contribute. If you do not make a choice within 6 seconds, the computer will randomly choose how many monetary units to contribute on your behalf, between 0 and 120.
>
> **No time pressure**
>
> The following session is NOT a TIME CONSTRAINT session.

The text depended on the player type variable:

> **10% players**
>
> In this round, if your group wins, the prize of 300 monetary units will be divided UNEQUALLY. You will receive 10% of the prize.

> **20% players**
>
> In this round, if your group wins, the prize of 300 monetary units will be divided UNEQUALLY. You will receive 20% of the prize.
>
> **30% players**
>
> In this round, if your group wins, the prize of 300 monetary units will be divided UNEQUALLY. You will receive 30% of the prize.
>
> **40% players**
>
> In this round, if your group wins, the prize of 300 monetary units will be divided UNEQUALLY. You will receive 40% of the prize.

The remainder of the text on the screenshot remained the same across all conditions.

A.3.5 Decision view

For each round, to make a contribution decision, participants saw a decision view (see a sample in Figure A.2).

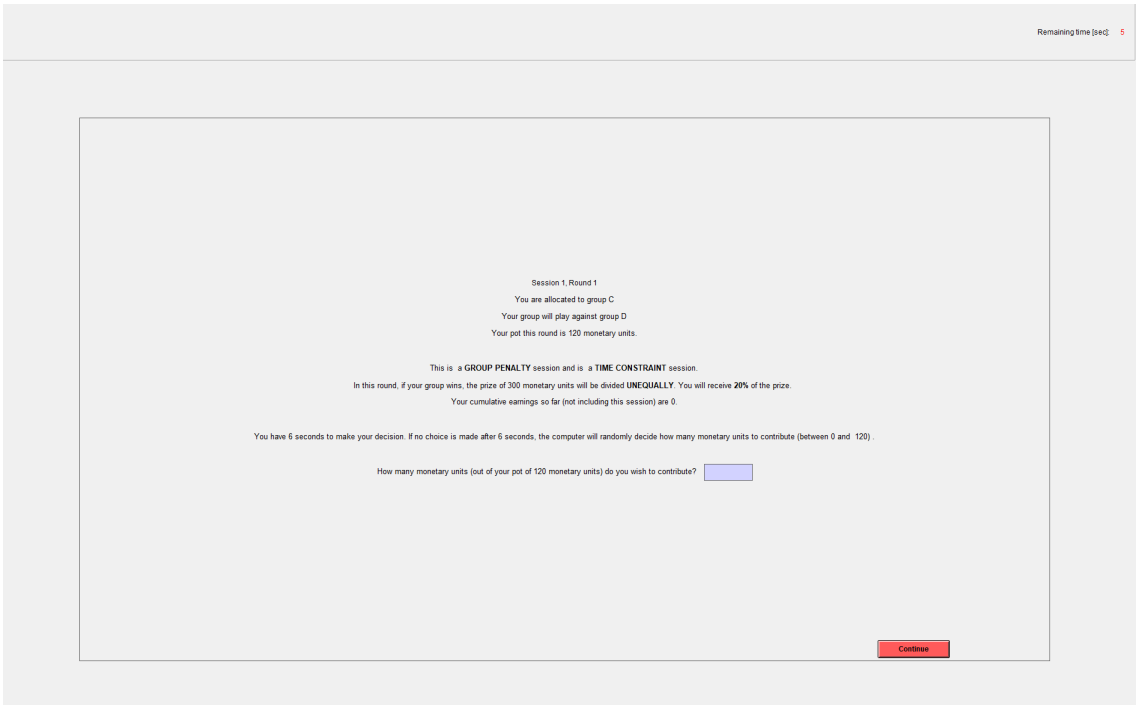


Figure A.2: Decision view in Experiment 1a

The text depended on the combination of the time constraint and group penalty variables:

> **With group penalty and with time pressure**
>
> The round is a GROUP PENALTY and is a TIME PRESSURE round.
>
> You have 10 seconds to make your decision.
>
> **Without group penalty and with time pressure**
>
> The round is NOT a GROUP PENALTY and is NOT a TIME PRESSURE round.
>
> **Without group penalty and with time delay**
>
> The round is NOT a GROUP PENALTY and is NOT a TIME PRESSURE round.
>
> You have to wait 10 seconds before you make your decision.
>
> **Without group penalty and with time delay**
>
> The round is a GROUP PENALTY and is NOT a TIME PRESSURE round.
>
> You have to wait 10 seconds before you make your decision.

The text depended on the player type variable:

> **10% players**
>
> In this round, if your group wins, the prize of 300 monetary units will be divided UNEQUALLY. You will receive 10% of the prize.
>
> **20% players**
>
> In this round, if your group wins, the prize of 300 monetary units will be divided UNEQUALLY. You will receive 20% of the prize.
>
> **30% players**
>
> In this round, if your group wins, the prize of 300 monetary units will be divided UNEQUALLY. You will receive 30% of the prize.
>
> **40% players**
>
> In this round, if your group wins, the prize of 300 monetary units will be divided UNEQUALLY. You will receive 40% of the prize.

The text depended on the time pressure condition:

Time pressure

You have 6 seconds to make your decision. If no choice is made after 6seconds, the computer will randomly decide how many monetary units to contribute (between 0 and 120) .

No time pressure

NO TEXT

The remainder of the text on the screenshot remained the same across all conditions.

A.3.6 Round outcome view

After the end of each round, participants saw a round outcome view (see a sample in Figure A.3).

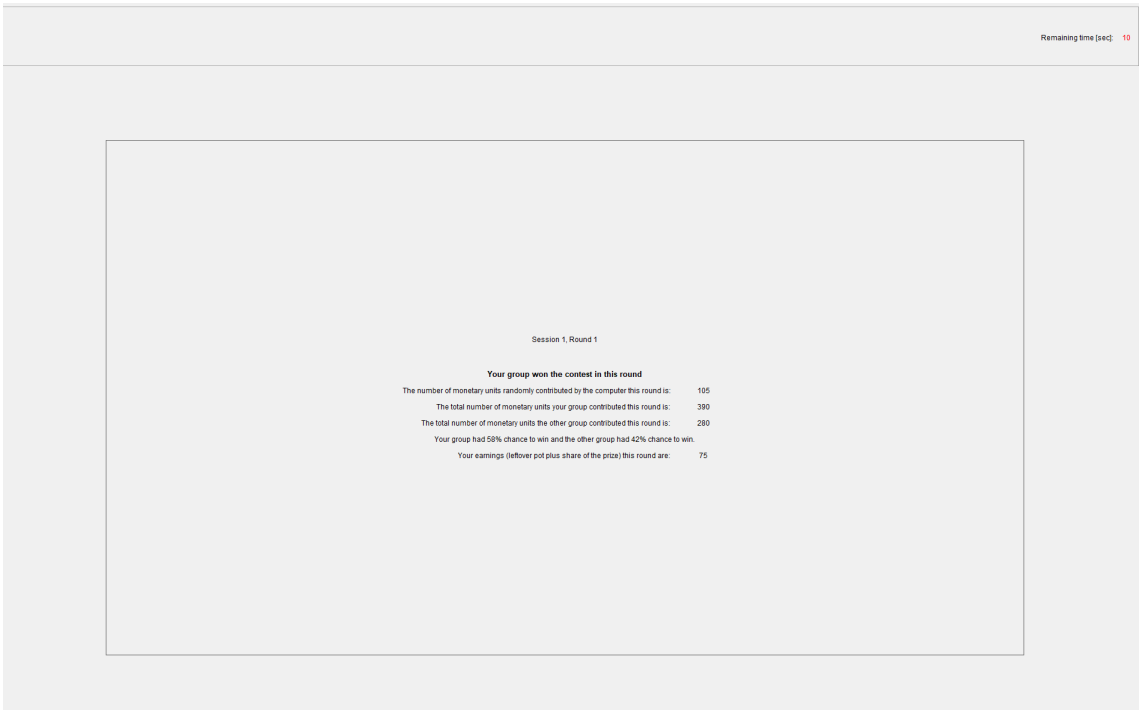


Figure A.3: Round outcome view in Experiment 1a

The information in the screenshot was the same across all conditions.

A.3.7 Period outcome view

After the end of each period, participants saw a period outcome view (see a sample in Figure A.4).

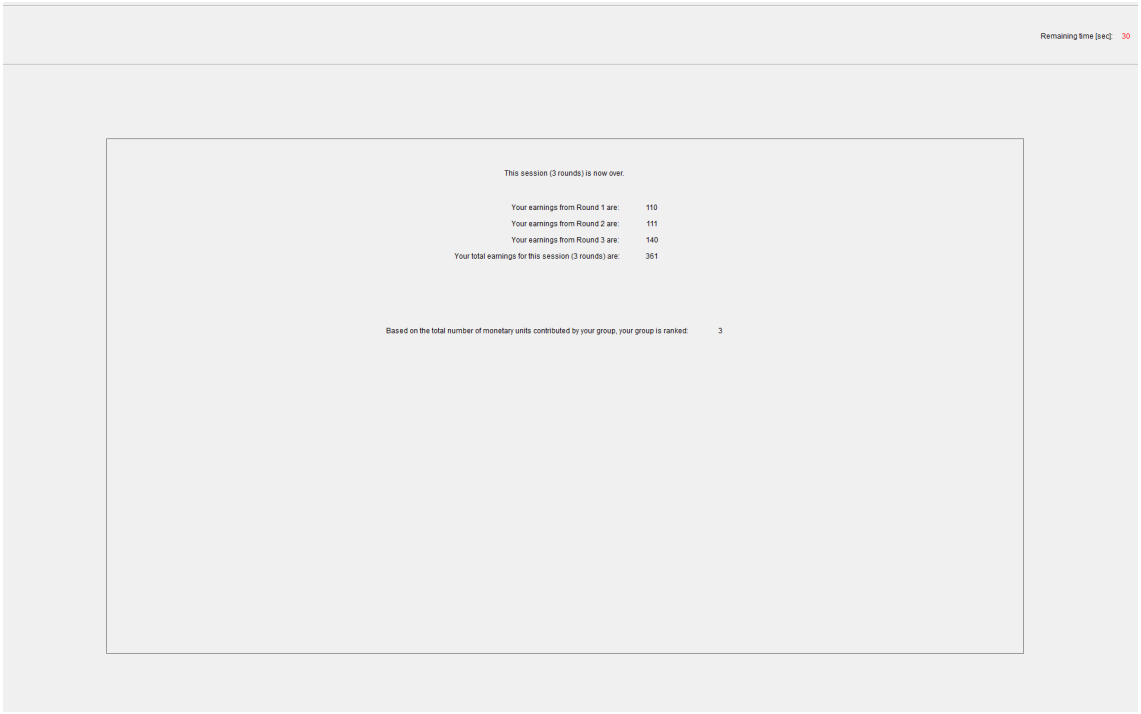


Figure A.4: Period outcome view in Experiment 1a

The information in the screenshot was the same across all conditions.

A.4 Models for Experiment 1a

For all models in Experiment 1a I removed the correlations between the random slopes and the interaction between the random-effects variables to simplify the structure of the model. This allowed for a successful execution without convergence errors.

A.4.1 Contribution model

In the contribution model, I did not interact the gender variable with all other independent variables, as some participant answered "Other" to the gender question, which made the number of data points for this level of the variable insufficient for an interaction analysis.

```
## model specification

contribution ~ contest_type*player_type*group_penalty*constraint+gender +

    (1 + player_type+group_penalty+constraint | id)
```

Table A.1: LME model for contribution in Experiment 1a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
contest type	1.18	1, 92.08	0.281	0.007
player type	45.10	3, 91.96	< 0.001 ***	0.081
group_penalty	70.95	1, 94	< 0.001 ***	0.049
constraint	0.31	1, 93.95	0.58	< 0.001
gender	0.12	2, 91.94	0.884	0.002
contest type:player type	0.14	3, 91.96	0.933	< 0.001
contest type:group_penalty	5.47	1, 94	0.021 *	0.004
player type:group_penalty	1.87	3, 933.93	0.132	0.001
contest type:constraint	0.70	1, 93.95	0.405	< 0.001
player type:constraint	0.66	3, 933.84	0.58	< 0.001
group_penalty:constraint	0.07	1, 934.23	0.794	< 0.001
contest type:player type:group_penalty	0.47	3, 933.93	0.701	< 0.001
contest type:player type:constraint	0.88	3, 933.85	0.449	< 0.001
contest type:group_penalty:constraint	0.27	1, 934.23	0.605	< 0.001
player type:group_penalty:constraint	0.41	3, 933.93	0.745	< 0.001
contest type:player type:group_penalty:constraint	0.41	3, 933.93	0.743	< 0.001

Table A.2: EMM contrasts of contribution for player type in Experiment 1a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	EMM	SE	DF	t-ratio	p	es
10% vs. 20%	-7.46	1.55	93.91	-4.80	< 0.001 ***	-0.40
10% vs. 30%	-19.25	1.86	93.99	-10.34	< 0.001 ***	-1.03
10% vs. 40%	-26.16	2.32	93.98	-11.29	< 0.001 ***	-1.40
20% vs. 30%	-11.79	1.74	93.97	-6.77	< 0.001 ***	-0.63
20% vs. 40%	-18.70	2.19	93.97	-8.54	< 0.001 ***	-1.00
30% vs. 40%	-6.91	1.61	93.94	-4.29	< 0.001 ***	-0.37

Table A.3: EMM contrasts of contribution for player type by group penatly and contest type in Experiment 1a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	contest type	group_penalty	EMM	SE	DF	t-ratio	p	es
10% vs. 20%	control	no_penalty	-7.53	2.92	277.31	-2.57	0.052 +	-0.40
10% vs. 30%	control	no_penalty	-20.73	3.25	212.99	-6.37	< 0.001 ***	-1.11
10% vs. 40%	control	no_penalty	-28.90	3.80	167.28	-7.61	< 0.001 ***	-1.54
20% vs. 30%	control	no_penalty	-13.21	3.13	235.78	-4.22	< 0.001 ***	-0.70
20% vs. 40%	control	no_penalty	-21.38	3.65	179.04	-5.85	< 0.001 ***	-1.14
30% vs. 40%	control	no_penalty	-8.17	2.98	260.87	-2.74	0.033 *	-0.44
10% vs. 20%	inter-group	no_penalty	-5.57	2.92	275.04	-1.91	0.226	-0.30
10% vs. 30%	inter-group	no_penalty	-21.00	3.25	212.99	-6.46	< 0.001 ***	-1.12
10% vs. 40%	inter-group	no_penalty	-27.10	3.80	167.28	-7.14	< 0.001 ***	-1.45
20% vs. 30%	inter-group	no_penalty	-15.43	3.12	233.92	-4.94	< 0.001 ***	-0.82
20% vs. 40%	inter-group	no_penalty	-21.53	3.65	177.86	-5.90	< 0.001 ***	-1.15
30% vs. 40%	inter-group	no_penalty	-6.10	2.98	260.87	-2.05	0.174	-0.33
10% vs. 20%	control	penalty	-7.79	2.91	272.86	-2.68	0.039 *	-0.42
10% vs. 30%	control	penalty	-18.86	3.25	212.99	-5.80	< 0.001 ***	-1.01
10% vs. 40%	control	penalty	-26.30	3.80	167.34	-6.93	< 0.001 ***	-1.40
20% vs. 30%	control	penalty	-11.07	3.11	232.12	-3.55	0.003 **	-0.59
20% vs. 40%	control	penalty	-18.51	3.64	176.79	-5.08	< 0.001 ***	-0.99
30% vs. 40%	control	penalty	-7.44	2.98	260.96	-2.49	0.063 +	-0.40
10% vs. 20%	inter-group	penalty	-8.95	2.93	278.15	-3.05	0.013 *	-0.48
10% vs. 30%	inter-group	penalty	-16.41	3.27	216.29	-5.02	< 0.001 ***	-0.88
10% vs. 40%	inter-group	penalty	-22.36	3.81	169.45	-5.87	< 0.001 ***	-1.19
20% vs. 30%	inter-group	penalty	-7.45	3.12	233.86	-2.39	0.082 +	-0.40
20% vs. 40%	inter-group	penalty	-13.40	3.65	177.88	-3.67	0.002 **	-0.71
30% vs. 40%	inter-group	penalty	-5.95	2.98	260.96	-2.00	0.192	-0.32

Table A.4: EMM contrasts of contribution for group penalty by contest type in Experiment 1a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	contest type	EMM	SE	DF	t-ratio	p	es
no_penalty vs. penalty	control	-11.16	2.59	93.90	-4.30	< 0.001 ***	-0.60
no_penalty vs. penalty	inter-group	-19.74	2.59	94.09	-7.61	< 0.001 ***	-1.05

Table A.5: EMM contrasts of contribution for contest type by group penalty in Experiment 1a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	group_penalty	EMM	SE	DF	t-ratio	p	es
control vs. inter-group	no_penalty	10.26	5.81	92.41	1.76	0.081 +	0.55
control vs. inter-group	penalty	1.68	5.79	92.39	0.29	0.773	0.09

A.4.2 Net benefit model

```
## model specification

net_payoff ~ contest_type*player_type*group_penalty*constraint+gender +

    (1 + player_type+group_penalty+constraint | id)
```

Table A.6: LME model of net benefit in Experiment 1a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
contest type	0.14	1, 92.05	0.704	< 0.001
player type	15.02	3, 91.94	< 0.001 ***	0.03
group_penalty	123.16	1, 93.97	< 0.001 ***	0.084
constraint	0.42	1, 93.93	0.521	< 0.001
gender	0.18	2, 91.92	0.838	< 0.001
contest type:player type	0.58	3, 91.94	0.627	0.001
contest type:group_penalty	8.35	1, 93.97	0.005 **	0.006
player type:group_penalty	0.22	3, 935.12	0.88	< 0.001
contest type:constraint	2.13	1, 93.93	0.148	0.001
player type:constraint	0.10	3, 935.03	0.961	< 0.001
group_penalty:constraint	6.51	1, 935.46	0.011	0.003
contest type:player type:group_penalty	0.23	3, 935.12	0.876	< 0.001
contest type:player type:constraint	0.42	3, 935.03	0.738	< 0.001
contest type:group_penalty:constraint	0.01	1, 935.46	0.924	< 0.001
player type:group_penalty:constraint	0.11	3, 935.12	0.953	< 0.001
contest type:player type:group_penalty:constraint	0.04	3, 935.12	0.989	< 0.001

Table A.7: EMM contrasts of net benefit for player type by group penalty and contest type in Experiment 1a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	group_penalty	contest type	EMM	SE	DF	t-ratio	p	es
10% vs. 20%	no_penalty	control	-8.90	5.79	334.83	-1.54	0.416	-0.22
10% vs. 30%	no_penalty	control	-12.74	5.85	315.71	-2.18	0.131	-0.32
10% vs. 40%	no_penalty	control	-22.12	6.29	259.67	-3.51	0.003 **	-0.56
20% vs. 30%	no_penalty	control	-3.85	6.00	300.71	-0.64	0.919	-0.10
20% vs. 40%	no_penalty	control	-13.22	6.14	284.64	-2.15	0.139	-0.33
30% vs. 40%	no_penalty	control	-9.37	6.50	241.30	-1.44	0.474	-0.24
10% vs. 20%	penalty	control	-10.16	5.75	329.91	-1.77	0.291	-0.26
10% vs. 30%	penalty	control	-18.02	5.85	315.71	-3.08	0.012 *	-0.46
10% vs. 40%	penalty	control	-29.07	6.30	259.77	-4.62	< 0.001 ***	-0.73
20% vs. 30%	penalty	control	-7.86	5.97	296.21	-1.32	0.553	-0.20
20% vs. 40%	penalty	control	-18.91	6.10	280.44	-3.10	0.011 *	-0.48
30% vs. 40%	penalty	control	-11.05	6.50	241.40	-1.70	0.326	-0.28
10% vs. 20%	no_penalty	inter-group	-9.79	5.77	332.32	-1.70	0.327	-0.25
10% vs. 30%	no_penalty	inter-group	-8.79	5.85	315.71	-1.50	0.437	-0.22
10% vs. 40%	no_penalty	inter-group	-20.04	6.29	259.67	-3.18	0.009 **	-0.51
20% vs. 30%	no_penalty	inter-group	1.00	5.98	298.41	0.17	0.998	0.03
20% vs. 40%	no_penalty	inter-group	-10.25	6.12	282.45	-1.68	0.339	-0.26
30% vs. 40%	no_penalty	inter-group	-11.25	6.50	241.30	-1.73	0.31	-0.28
10% vs. 20%	penalty	inter-group	-6.21	5.80	335.38	-1.07	0.708	-0.16
10% vs. 30%	penalty	inter-group	-9.48	5.88	320.47	-1.61	0.374	-0.24
10% vs. 40%	penalty	inter-group	-17.47	6.33	263.69	-2.76	0.031 *	-0.44
20% vs. 30%	penalty	inter-group	-3.27	5.99	298.44	-0.55	0.948	-0.08
20% vs. 40%	penalty	inter-group	-11.26	6.12	282.57	-1.84	0.257	-0.28
30% vs. 40%	penalty	inter-group	-7.99	6.50	241.40	-1.23	0.609	-0.20

A.5 Materials for Experiment 1b

A.5.1 Instructions

Instruction 1: About the study

> Welcome!
>
> You are about to take part in a decision-making experiment.

Instruction 2: Earnings

> You will be paid in private and in cash at the end of the experiment.
>
> The amount you will receive depends on your decisions, so please follow the instructions carefully.
>
> During the experiment you will have the chance to earn monetary units, which will be converted into cash at the end of today's session.
>
> The exchange rate is 1 monetary unit = £0.00221.

Instruction 3: Sessions and rounds

> **Inter-group contests** The study includes 4 sessions, each including 3 rounds.
>
> In each round, your group will compete against another group in a contest game for a prize.
>
> There are four groups playing at any one time.

> **Control contests** The study includes 4 sessions, each including 3 rounds.
>
> In each round, your group will play a game for a prize.
>
> There are four groups playing at any one time.

Instruction 4: Group formation

> At the beginning of each session you will be randomly matched with 3 other participants to form a group of 4.
>
> Each participant in this room will be a member of one group.
>
> After the end of each session you will be randomly matched again with 3 players

to form a new group.

Instruction 5: Anonymity

The experiment is completely anonymous.

The participants' identity will not be revealed, neither during nor after today's study.

You will not know who your group mates are, and they will not know who you are.

Instruction 6: Your options

Inter-group contests You will begin each round with a "pot" of 75 monetary units.

You can contribute any amount from this pot to your group's success in a contest against another group.

Any amount you decide to keep will be added to your total earnings from the round.

Your group mates and members of the other group will have the option to contribute to the contest in the same way as you do.

Control contests You will begin each round with a "pot" of 75 monetary units.

You can contribute any amount from this pot to your group's success in the game.

Any amount you decide to keep will be added to your total earnings from the round.

Your group mates will have the option to contribute to the game in the same way as you do.

Instruction 7: The prize

Inter-group contests In each round your group will be in a contest with another group for a prize of 300 monetary units.

At the end of each round, the chance to win this prize is determined by the total contributions by members of your group, compared to the total contributions

by members of the other group.

If your group contributed 60 monetary units overall, while the other group contributed 40, your group will have a 60% chance of winning the prize, while the other group will have a 40% chance.

Control contests In each round your group will play a game for a prize of 300 monetary units.
At the end of each round, the chance to win this prize is determined by the total contributions by members of your group. The more monetary units your group contributes, the more likely it will win the prize.
If your group contributed 60 monetary units overall, your group will have a higher chance of winning the prize, compared to a situation when it contributed 40 monetary units.

Instruction 8: Earnings

If your group wins the contest, the prize will be divided equally among group members. This means that each group member will receive 25% of the prize.

Instruction 9: Sessions with group penalty

Remember, each session includes 3 rounds.

Some sessions are group penalty sessions.
At the end of these sessions, your group's total contribution will be compared to those of the other 3 groups.
The group with the smallest total contribution has a 50% chance of being penalized.
If your group is penalized, you lose all your earnings from the session. This includes:

1. any "leftovers" (i.e. any amounts from your pots you did not contribute), across the 3 rounds;

> 2. any shares of the prize you received, across the 3 rounds.

Instruction 10: Sessions without group penalty

> Other sessions are not group penalty sessions.
>
> At the end of these sessions, groups will not be penalized.
> At the beginning of each session, you will find information about whether the session is a group penalty session.

Instruction 11: Sessions with time constraint

> Some sessions are time constraint sessions.
>
> In these sessions, in each round you have 6 seconds to make your decision.
> If you do not make your decision within 6 seconds, the computer will randomly "decide" your contribution for the round.

Instruction 12: Sessions without time constraint

> Other sessions are not time constraint sessions.
>
> In these sessions, in each round you have unlimited time to make your decision.
> At the beginning of each session, you will find information about whether the session is a time constraint session. This information will be on your screen while you make your decision.

A.5.2 Quiz

Participants solved a short quiz before the beginning of the actual experiment.

Quiz instructions

> Now we will ask you questions about the rules of the game. Please ask the experimenter if you have any further questions.

Question 1

Inter-group contests What determines your chance of winning the contest?

1. **Your group's contributions and the contributions of the other group.**
2. Mainly your group's contributions.
3. It is randomly determined.

Answer: The correct answer is 1). The probability of winning the prize is determined by the total contribution of the members of your group during the round and that of the members of the other group.
For example, if your group contributed 30 monetary units overall, while the other group contributed 70, your group will have a 30% chance of winning the prize, while the other group will have a 70% chance.

Control contests What determines your chance of winning the prize?

1. Your group's contributions and the contributions of the other groups.
2. **Mainly your group's total contribution.**
3. It is randomly determined.

Answer: The correct answer is 2). The probability of winning the prize is mainly determined by the total contribution of the members of your group during the round.
For example, if your group contributed 30 monetary units overall, your group will have a smaller chance of winning the prize, compared to a situation when it contributed 70 monetary units.

Question 2

> In one round, you contributed 50 of your 75 monetary units, and your group wins the prize of 300 monetary units. What are your total earnings for this round?
>
> 1. **100**
> 2. 200
> 3. 120

> Answer: The correct answer is 1). You have 25 monetary units leftover from your pot $(75 - 50)$ and you receive 75 monetary units from the prize (25% of 300).

Question 3

> In a group penalty session, what happens at the end of the session if your group has the smallest total group contribution compared to the other groups?
>
> 1. Your group will be certainly penalized.
> 2. **Your group has a 50% chance of being penalized.**
> 3. Nothing will happen.

> Answer: The correct option is 2). In group penalty sessions, the group with the smallest total contribution has a 50% chance of being penalized. If your group is penalized, you lose all your earnings from the session.

Question 4

> In a session with time constraint, how many seconds do you have to make your decision?
>
> 1. 15 seconds
> 2. 120 seconds

3. **6 seconds**

Answer: The correct option is 3). With time constraint, you have 6 seconds to make your decision . Please, ask the experimenter if you have any additional questions!

Now you will play one training session of 3 rounds.

A.5.3 Training round

Participants played 3 training rounds with the experimental software. In all round, all participants received an equal share of the prize.

A.5.4 Period information view

Before the beginning of each period, participant saw an information view (see a sample in Figure A.5).

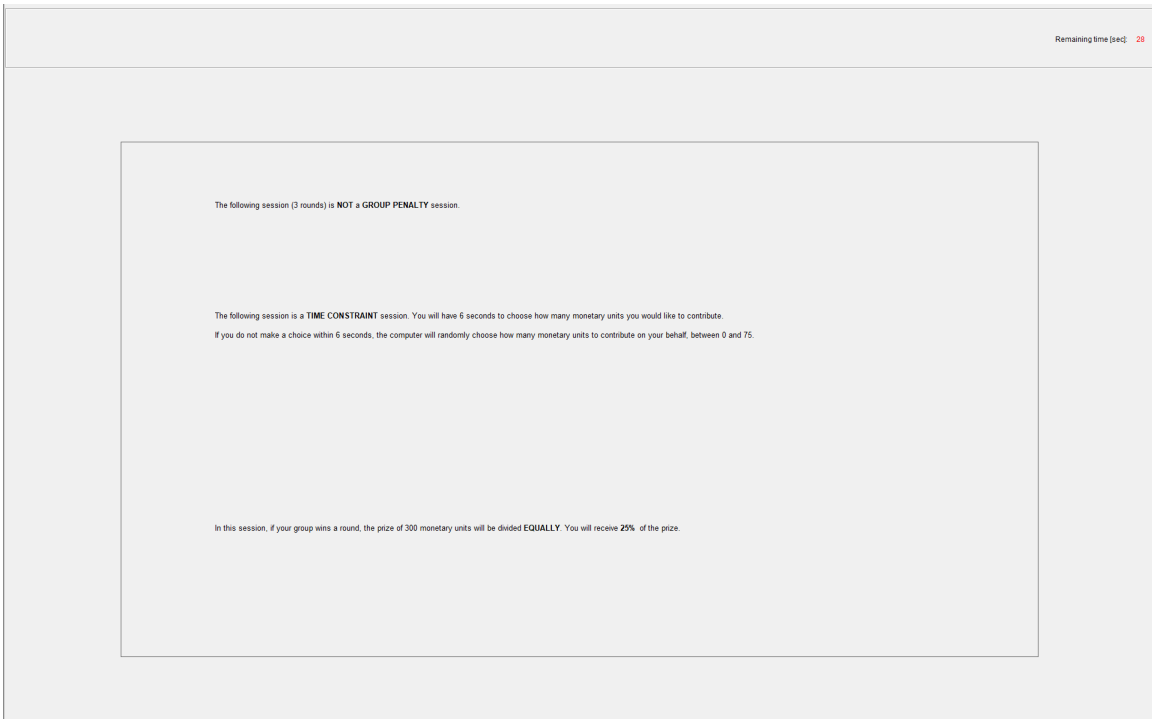


Figure A.5: Period information view for Experiment 1b

The text depended on the group penalty condition:

Group penalty

The following session is a GROUP PENALTY session. At the end of the session, the groups' total contributions over the 3 rounds will be compared. The group with the smallest total contribution will have a 50% chance of losing all its earnings from the session

No group penalty The following session is NOT a GROUP PENALTY session.

The text depended on the time pressure condition:

Time pressure

The following session is a TIME CONSTRAINT session. You will have 6 seconds to choose how many monetary units you would like to contribute. If you do not make a choice within 6 seconds, the computer will randomly choose how many monetary units to contribute on your behalf, between 0 and 120.

No time pressure

The following session is NOT a TIME CONSTRAINT session.

The remainder of the text on the screenshot remained the same across all conditions.

A.5.5 Decision view

For each round, to make a contribution decision, participants saw a decision view (see a sample in Figure A.6).

The text depended on the combination of the time constraint and group penalty variables:

With group penalty and with time pressure

The round is a GROUP PENALTY and is a TIME PRESSURE round.

You have 10 seconds to make your decision.

Without group penalty and with time pressure

The round is NOT a GROUP PENALTY and is NOT a TIME PRESSURE round.

Without group penalty and with time delay

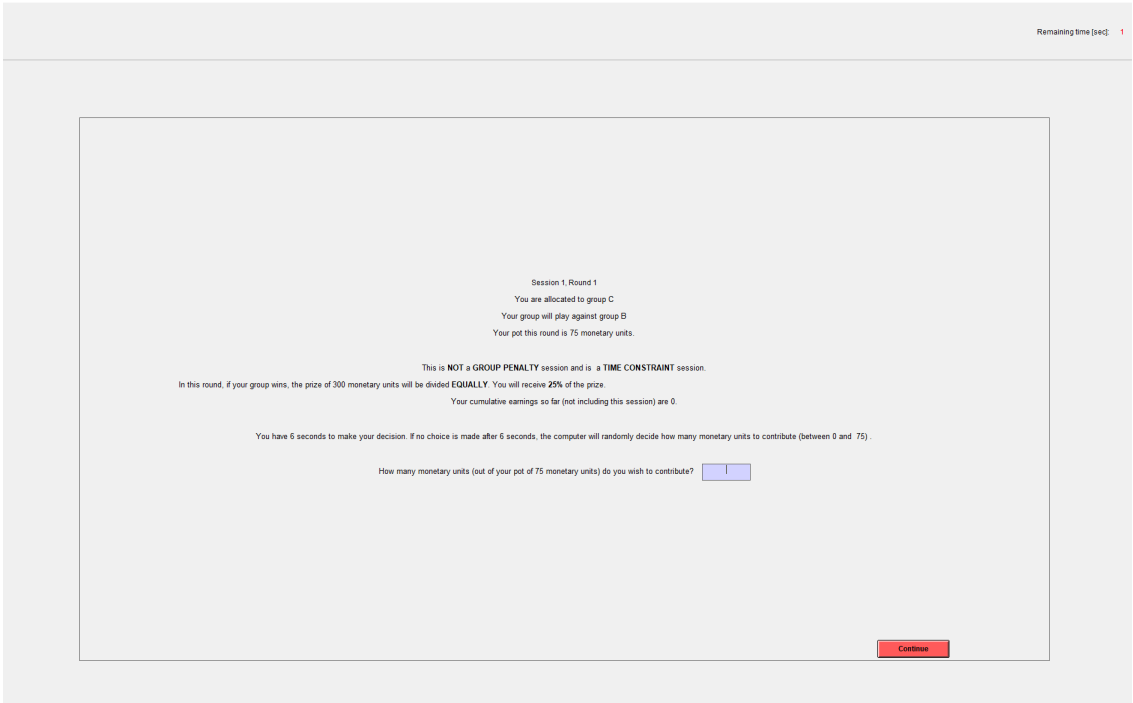


Figure A.6: Decision view for Experiment 1b

> The round is NOT a GROUP PENALTY and is NOT a TIME PRESSURE round.
>
> You have to wait 10 seconds before you make your decision.
>
> **Without group penalty and with time delay**
>
> The round is a GROUP PENALTY and is NOT a TIME PRESSURE round.
>
> You have to wait 10 seconds before you make your decision.

The text depended on the time pressure condition:

> **Time pressure**
>
> You have 6 seconds to make your decision. If no choice is made after 6seconds, the computer will randomly decide how many monetary units to contribute (between 0 and 120) .
>
> **No time pressure**
>
> NO TEXT

The remainder of the text on the screenshot remained the same across all conditions.

A.5.6 Round outcome view

After the end of each round, participants saw a round outcome view (see a sample in Figure A.7).

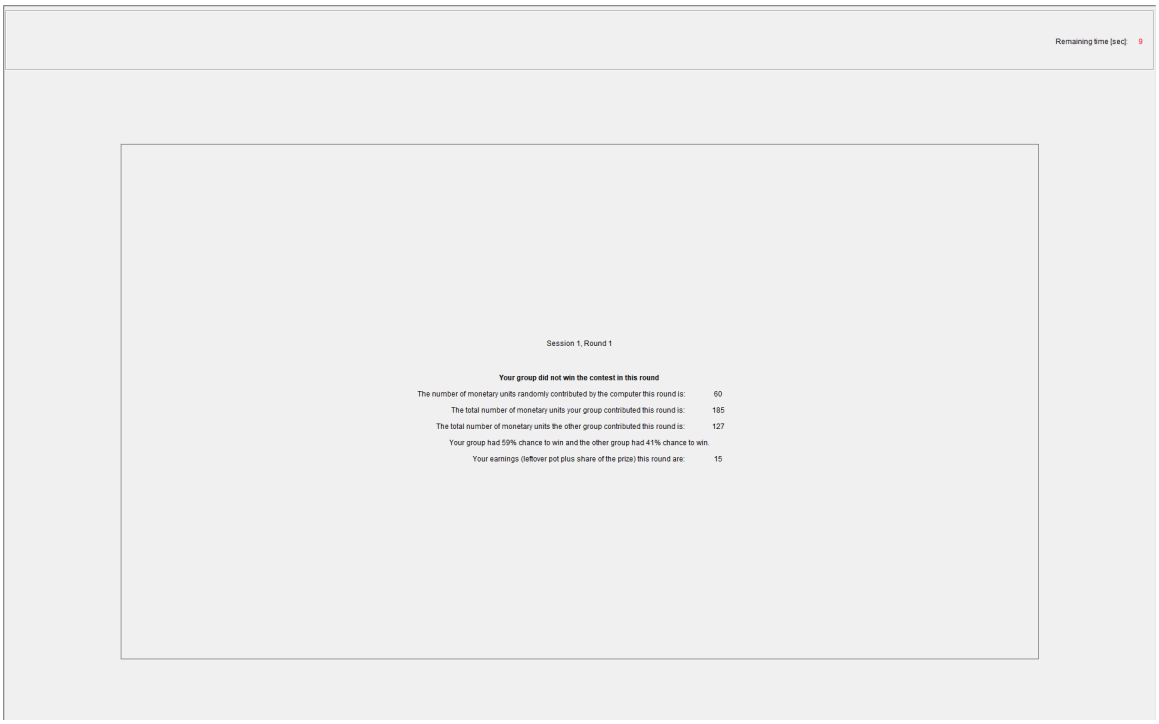


Figure A.7: Round outcome view for Experiment 1b

The information in the screenshot was the same across all conditions.

A.5.7 Period outcome view

After the end of each period, participants saw a period outcome view (see a sample in Figure A.8).

The information in the screenshot was the same across all conditions.

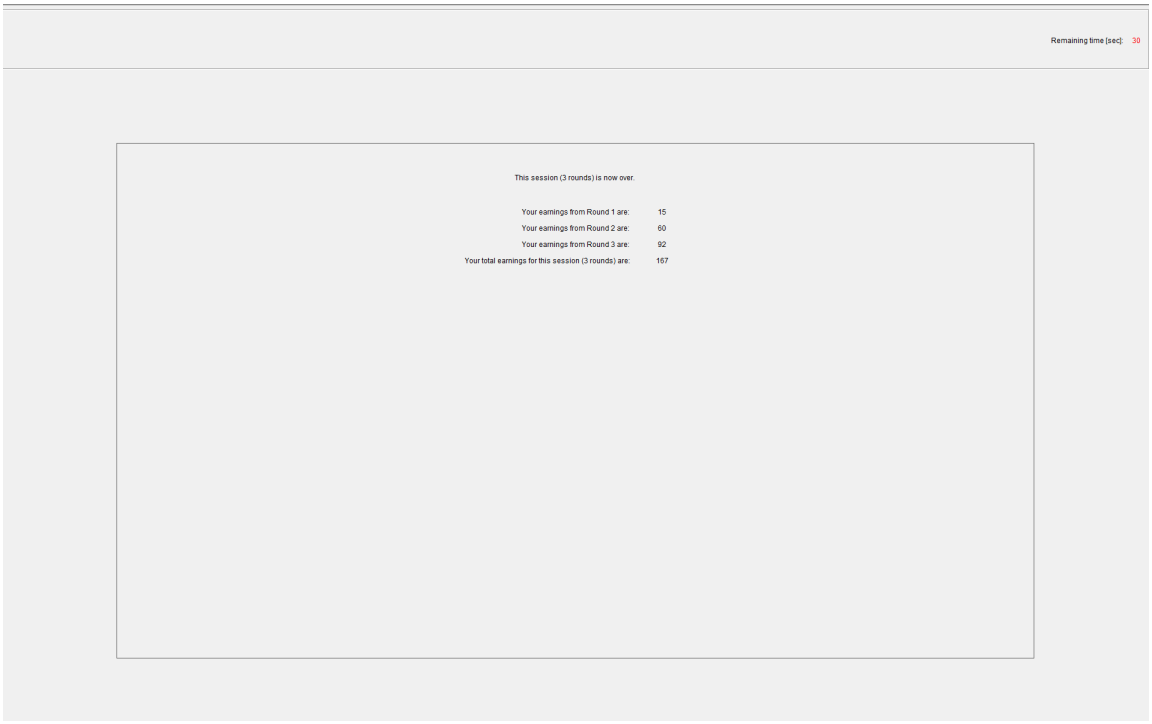


Figure A.8: Period outcome view for Experiment 1b

A.6 Models for Experiment 1b

For all models in Experiment 1b I removed the correlations between the random slopes and the interaction between the random-effects variables to simplify the structure of the model. This allowed for a successful execution without convergence errors.

A.6.1 Contribution model

```
## model specification

contribution ~ contest_type*constraint*group_penalty+gender +

    (1 + pressure+group_penalty | id)
```

Table A.8: LME model of contribution for Experiment 1b Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
contest type	0.00	1, 92	0.966	< 0.001
constraint	1.27	1, 93.83	0.263	< 0.001
group_penalty	48.30	1, 93.98	< 0.001 ***	0.085
gender	1.86	2, 91.97	0.162	0.026
contest type:constraint	1.14	1, 93.83	0.288	< 0.001
contest type:group_penalty	7.60	1, 93.98	0.007 **	0.014
constraint:group_penalty	0.06	1, 93.83	0.805	< 0.001
contest type:constraint:group_penalty	2.25	1, 93.83	0.137	0.002

Table A.9: EMM contrasts of contribution for group penalty by contest type in Experiment 1b. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	contest type	EMM	SE	DF	t-ratio	p	es
no_penalty vs. penalty	control	-18.84	2.75	94.23	-6.86	< 0.001 ***	-1.61
no_penalty vs. penalty	inter-group	-8.14	2.74	93.72	-2.97	0.004 **	-0.70

Table A.10: EMM contrasts of contribution for group penalty by contest type in Experiment 1b. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	group_penalty	EMM	SE	DF	t-ratio	p	es
control vs. inter-group	no_penalty	-5.19	4.24	137.87	-1.22	0.223	-0.44
control vs. inter-group	penalty	5.51	4.24	137.52	1.30	0.196	0.47

A.7 Models for group comparison in Study 1

A.7.1 Contribution model

Table A.11: ANOVA model of relative total contribution in Study 1. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Pes
contest type	1.28	1, 464	0.259	0.003
system type	48.67	1, 464	< 0.001 ***	0.095
constraint	0.20	1, 464	0.655	< 0.001
group_penalty	85.03	1, 464	< 0.001 ***	0.155
contest type:system type	3.88	1, 464	0.049 *	0.008
contest type:constraint	0.48	1, 464	0.487	0.001
system type:constraint	0.24	1, 464	0.626	< 0.001
contest type:group_penalty	1.30	1, 464	0.255	0.003
system type:group_penalty	2.53	1, 464	0.112	0.005
constraint:group_penalty	0.01	1, 464	0.903	< 0.001
contest type:system type:constraint	0.03	1, 464	0.856	< 0.001
contest type:system type:group_penalty	10.42	1, 464	0.001 **	0.022
contest type:constraint:group_penalty	0.25	1, 464	0.615	< 0.001
system type:constraint:group_penalty	0.00	1, 464	0.984	< 0.001
contest type:system type:constraint:group_penalty	0.61	1, 464	0.433	0.001

Table A.12: EMM contrasts of relative total contribution for system type by contest type and group penalty in Study 1. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	contest type	group_penalty	EMM	SE	DF	t-ratio	p	es
hierarchy vs. egalitarianism	control	no_penalty	-0.31	3.37	464.00	-0.09	0.926	-0.02
hierarchy vs. egalitarianism	inter-group	no_penalty	-17.82	3.37	464.00	-5.29	< 0.001 ***	-1.21
hierarchy vs. egalitarianism	control	penalty	-16.54	3.37	464.00	-4.91	< 0.001 ***	-1.12
hierarchy vs. egalitarianism	inter-group	penalty	-12.31	3.37	464.00	-3.65	< 0.001 ***	-0.83

B

Study 2

B.1 Methods

Both Experiment 2a and Experiment 2b followed a similar experimental procedure as Study 1 and were executed online with Mechanical Turk participants.

Mechanical Turk Typically, Mechanical Turk participants are considered more diverse than standard subject pools in behavioural experiments (Buhrmester, Kwang, & Gosling, 2011). Such samples are considered viable for behavioural evolutionary research (Rand, 2012) and yield similar results to controlled laboratory studies in most classical cognitive tasks (Crump, McDonnell, & Gureckis, 2013) and experimental games (Arechar, Gächter, & Molleman, 2017). The recruitment and the payments were administered by the Nuffield Centre for Experimental Social Sciences.

Procedure Participants in both studies read information sheets, signed consent forms, went through a number of slides with the game instructions, and solved a short quiz. After the initial stage all participants were asked to make a number of decisions regarding their contribution preferences in various contest games, which represent combinations of the within-subject independent variables.

Contest game In the actual experiment, participants were told that they will be matched with three other players to form groups of four players and will play several contest games, as the one introduced in Study 1.

Manipulations As in Study 1, the difference between the two experiments in Study 2 was the group's system type. In Experiment 2a participants were told that their group is hierarchical. In such groups, two of the four players earned 40% of the prize, if their group wins the contest, while the remaining two players earned only 10% of the prize. In Experiment 2b participants were told that their group is egalitarian, thus the prize was divided equally between participants.

Across both experiments I manipulated three independent variables. First, I manipulated the specific contest type participants played in the game. Some participants played inter-group contests, while other participants played control contests. Second, in some cases each participant was told that the four groups in the session are going to be arranged based on their total contribution, which was defined as the sum of all individual contribution preferences within the group. Only the 1st group had no chance of being penalized, while the other three groups received a probability reversely proportional to their rank. Finally, I manipulated whether participants made their decisions under a time pressure of 10 second or under a time delay of 10 seconds.

Payments All participants were paid a \$0.4 show-up fee and an average earning from the experiment of \$0.6, which was based on their performance during the

experimental study. The monetary units were converted to US dollars at an exchange rate of 1 monetary unit = \$0.0016 for Study 2a and 1 monetary unit = \$0.002 for Study 2b. The differences between the exchange rates were due to the differences between the endowments.

Ethics Experiment 2a and Experiment 2b were approved by Departmental Research Ethics Committee, School of Anthropology and Museum Ethnography, University of Oxford; Nuffield Centre for Experimental Social Science, University of Oxford; Institutional Review Board, University of Tennessee, Knoxville; U.S. Army Research Office; and Oxford Tropical Research Ethics Committee.

Group-level comparison As in Study 1, to test the hypothesis that hierarchical groups will outperform egalitarian groups during "us vs. them" problems, I aggregated the group-level data from both experiments in Study 2 and compared the performance of hierarchical vs. egalitarian groups.

B.2 Simulation

Study 2 was executed asynchronously and without feedback. This means that participants were just asked to make several decisions and did not receive feedback about their and their group's performance. To calculate the net benefits of participants based on their decisions, I had to simulate multiple unfolds of the game.

Both experiments from Study 1 were executed in laboratory settings. Participants were randomly assigned to sessions and groups and in some cases each group was randomly matched with another group to play a Tullock contest. The average net benefits of players were thus highly dependent on these random elements. For instance, if a contributor is assigned to a group of non-contributors, his/her net benefit is likely to be smaller than when s/he is assigned to a group of contributors. If a group of non-contributors is matched with a group of contributors to play a contest, the benefits of the non-contributors will be likely reduced as winning the contest will be less likely.

As the distribution of net benefits is highly dependent on such stochastic factors, I executed a Monte Carlo simulation. The simulation aimed to sample the distribution of net benefits of each decision by running a simulated game multiple times with new randomly selected parameters (e.g. new assignments and matchings). In other words, for each decision, the simulation produces a sampled distribution with net benefits. The average of this sampled distribution is the expected net benefit. Thus, for each participant who finished the study, the simulation uses his/her decisions as an input to produce his/her expected net benefits as an output. An overview of all steps can be seen in Figure B.1.

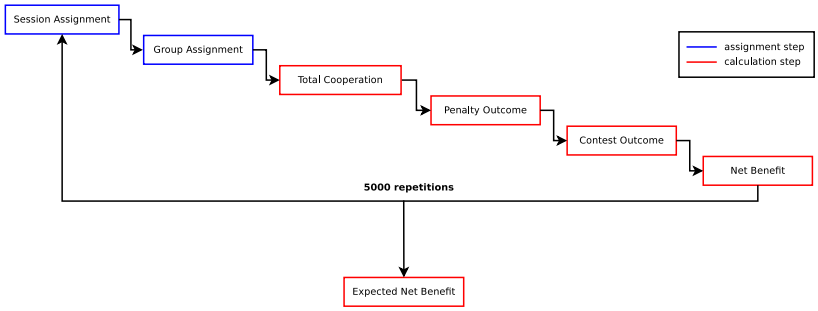


Figure B.1: Graphical representation of the Monte Carlo simulation structure for Study 2.

Development The simulation software was developed in the programming language R.

Simulation steps The simulation was divided into seven steps. In this subsection I will aim to illustrate the general goal and the precise calculations of each step. The simulation replicated most of the setup from the laboratory experiments from Study 1.

Step 1: Assignment to sessions Each player was randomly assigned to a session of 16 participants (e.g. the same number of players per session as in Study 1).

Step 2: Assignment to groups In each session, all 16 players were randomly assigned to four groups of four players. If the group was hierarchical, half of these participants were of high rank, while the remaining half were of low rank.

Step 3: Calculation of group's total contribution The total contribution of each group (X_i) was calculated with the following equation:

$$X_i = \sum_{i=1}^{N} x_i \tag{B.1}$$

where x_i is the contribution of player i of the focal group and N is the number of players in the focal group, equal to four in this study.

Step 4: Calculation of penalty outcomes Groups in each session were ranked based on their total contribution. Each group received a probability of being penalized (S_i), based on its rank. The group with highest total contribution received P = 0 of being penalized, while the group with lowest total contribution received the highest probability, as expressed by the following equation:

$$S_i = \begin{cases} 0, & \text{if rank } = 1 \\ 0.25, & \text{if rank } = 2 \\ 0.5, & \text{if rank } = 3 \\ 0.75 & \text{if rank } = 4 \end{cases}$$

After all probabilities were calculated, the simulation executed a Bernoulli trial for each group to determine its penalty outcome. The Bernoulli trial took as an input the probability of penalty and returned one of two outcomes: "penalized" or "not penalized". If the group was penalized, all its members received a net benefit of 0 from their decision.

Step 5: Calculation of contest outcomes In inter-group contests, groups in each session were matched in pairs. Each group played a contest against the other group in its pair, based on the standard Tullock function, e.g. $P_i = \frac{X_i}{X_i+X_j}$, where the group with higher total contribution had a higher probability of winning the prize of 300 monetary units. If $X_i = X_j$, one group was selected randomly to win the prize. In control contests, groups played against the experimental software. The simulation used the distribution of total contributions (X_j) from the inter-group contests to determine the distribution of experimental software's contribution.

Once the winning probability of each group was calculated, in the inter-group

contests the simulation software executed a Bernoulli trial to determine which group wins the contest in each pair or against the experimental software. The outcome was based on the respective winning probabilities of both groups. In control contests, the winning probabilities were independent, thus the simulation executed the Bernoulli trial separately for each group.

Step 6: Calculation of net benefits Once the penalty outcomes and the contest outcomes were calculated, the simulation estimated the net benefit for each decision. If the penalty outcome was "not penalized", the net benefit was calculated as $b_i = l_i^c + w_i$, where b_i is the net benefit for player i, l_i^c is the leftover from the pot (or endowment) for player i, and w_i is the share of the prize won by player i. However, if the penalty outcome was "penalized", the net benefit of player i was directly set to 0 (e.g. $b_i = 0$). The leftover from the pot (l_i^c) was calculated as e_i- x_i, where e_i is the endowment and x_i is the contribution decision of player i. The share of the prize (w_i) was calculated as $w_i = P \times m_i$ if player i's group has won the contest. P is the contest prize (set to 300 monetary units) while m_i is a multiplier, which was based on player i's rank. In Study 1a, high-rank players received $m_i = 0.4$, or 40% of the prize, while low-rank players received an $m_i = 0.1$, or 10%. In Study 2b, as all groups were egalitarian, all participants received $m_i = 0.25$ or 25% of the prize. If player i's group has not won the contest, his/her share of the prize was set to 0 (e.g. $w_i = 0$).

Step 7: Calculation of expected net benefits Finally, all simulation steps (1 to 6) were repeated 5000 times. The expected net benefit for each decision was calculated over all repetitions with the following equation:

$$E[b_i] = \frac{\sum_{j=1}^{N} b_{ij}}{NR} \tag{B.3}$$

where $E[b_i]$ is the expected net benefit for decision i, b_{ij} is the net benefit for decision

i at repetition j, and NR is the number of repetitions (e.g. 5000).

B.3 Analytical framework

For each dependent variable of interest, I constructed a linear mixed effects model (LME). For all models, I started with the maximal possible random structure, justified by the experimental design and the limitations of the data. I conducted contrast comparisons, based on the estimated marginal means (EMM) from the LME models, to test the experimental hypotheses and to investigate interaction effects.

B.4 Materials for Experiment 2a

B.4.1 Instructions

Instruction 1

> You will be paid after the end of the experiment, based on your performance.
>
> The amount you will receive depends on your decisions, so please follow ALL instructions carefully.
>
> You will be later quizzed on your understanding of the game, so it is vital to understand its rules.
>
> Your current decisions will be matched with the decisions of other participants in the experiment a couple of days after its end. Based on your and their performance, you will have the chance to earn monetary units which will be converted to US dollars at an exchange rate of 1 monetary unit = \$0.0016 which is 100 monetary units = \$0.16.
>
> You will receive your earnings approximately 4 weeks after the end of the session directly into your account.
>
> You will receive your show-up fee (\$0.40) after the end of today's session and on average \$0.60 in bonus payments.

Instruction 2

> Before the actual instructions, you will be assigned a status level dependent on your performance in a painting pricing task. You will be either a leader or a low status player.
>
> Press the button to start the task.

Instruction 3

> PAINTING PRICING TASK
>
> When you click the button, you will see a famous painting by a Flemish Baroque painter.

> You will be asked to evaluate the price of this painting.
>
> After you make your decision, you will receive further instructions.

Instruction 4

Participants were given a painting of a famous author (see Figure B.2). Then they were divided into high- and low-rank players, based on whether they overestimated or underestimated the price of the task.



Figure B.2: Painting naming task in Experiment 2a

The were asked the following question:

> What is the price of the painting?
>
> 1. $76.6 million
> 2. $76.7 million

Instruction 5

High-rank individuals

The price of the painting is indeed $76.7 million. You have correctly estimated it!

Because of your decision, in this experiment you have been assigned to be a leader in your group.

Congratulations!

As a leader, you are responsible for the success of your group.

The fact that you are a leader is indicated by the number of stars you will receive on your screen.

Leaders, like you, receive 3 stars.

Other players have received low status (they are not leaders), which means that they receive only 1 star.

Low-rank individuals The price of the painting is $76.7 million. You have underestimated its value.

Because of your decision, in this experiment you have been assigned a low status!

The status is indicated by the number of stars you will receive on your screen.

Low status players, like you, receive only 1 star.

Other players are leaders, which means that they receive 3 stars.

Instruction 6: Rounds

Inter-group contests The study includes 4 rounds. In each round you will have to make one decision.

In each round, your group will compete against another group in a contest game for a prize.

There are 4 groups playing at any one time (in fact, the groups will be matched in the post-game simulation).

In each round, you will play directly against only 1 of these 4 groups for the prize.

Control contests The study includes 4 rounds. In each round you will have to make one decision.

In each round, your group will play a game for a prize.

There are 4 groups playing at any one time (in fact, the groups will be matched in the post-game simulation).

Instruction 7: Group Formation

At the beginning of each round you are randomly matched with 3 other participants to form a group of 4 participants.

After the end of each round you will be randomly matched again with 3 participants to form a new group of 4 participants.

In each group, 2 players are LEADERS while the other 2 players have LOW STATUS.

Instruction 8: Anonymity

The experiment is completely anonymous.

The participants' identity will not be revealed, neither during nor after today's study.

You will not know who your group mates are, and they will not know who you are.

Instruction 9: Your options

You will begin each round with a "pot" of 120 monetary units.

You can contribute any amount from this pot to your group's success in a contest against another group.

Any amount you decide to keep will be added to your total earnings from the round.

Your group mates and members of the other group will have the option to contribute to the contest in the same way as you do.

Instruction 10: The prize

Inter-group contests In each round your group will be in a contest with another group for a prize of 300 monetary units.

At the end of each round, the chance to win this prize is determined by the total contributions by members of your group, compared to the total contributions by members of the other group.

EXAMPLE: If your group contributed 60 monetary units overall, while the other group contributed 40, your group will have a 60% chance of winning the prize, while the other group will have a 40% chance.

Control contests In each round your group will play a game for a prize of 300 monetary units.

At the end of each round, the chance to win this prize is determined by the total contributions by members of your group. The more monetary units your group contributes, the more likely it will win the prize.

EXAMPLE: If your group contributed 60 monetary units overall, your group will have a higher chance of winning the prize, compared to a situation when it contributed 40 monetary units.

Instruction 11: Earnings

If your group wins the contest, the prize will be divided unequally among the 4 group members.

The 2 leaders will receive 40% of the prize, while the other 2 low status players will receive 10% of the prize.

Instruction 12: Rounds with group penalty

Rounds with group penalty

Remember, the experiment has 4 rounds.

There are 4 groups playing in any one round at the same time (in fact, the

groups will be matched in the post-game simulation).

Some rounds are group penalty rounds.

At the end of these rounds, your group's total contributions will be compared to those of the other 3 groups.

Based on the relative rank of your group, your group will be penalized with a different probability.

- If your group is 1st, you will not be penalized;
- If your group is 2nd, you will have 25% chance of being penalized;
- If your group is 3rd, you will have 50% chance of being penalized;
- If your group is 4th, you will have 75% chance of being penalized.

If your group is penalized, you lose all your earnings from the round. This includes:

- any "leftovers" in your pot (i.e. any amounts from your pot you did not contribute);
- any share of the prize you received.

Instruction 13: Rounds without group penalty

Other rounds are not group penalty rounds.

At the end of these rounds, groups will not be ranked and penalized.

At the beginning of each round, you will find information about whether the round is a group penalty round.

This information will be on your screen while you make your decision.

Instruction 14: Rounds with time pressure

Some rounds are time constraint rounds.

In these rounds you have 10 seconds to make your decision.

> If you do not make your decision within 10 seconds, the computer will randomly "decide" your contribution for that round.

Instruction 15: Rounds without time pressure

> Other rounds are not time constraint rounds.
>
> In these rounds you have to wait 10 seconds before you make your decision.
> At the beginning of each round, you will find information about whether the round is a time constraint round. This information will be on your screen while you make your decision.

B.4.2 Quiz

Before the beginning of the actual experiment, participants filled a quiz.

Quiz instructions

> Now we will ask you questions about the rules of the game.
>
> Please, try to answer them as well as possible!
> After you answer each question, you will see the correct answer.

Question 1

> **Inter-group contest**
>
> What determines your chance of winning the contest?
>
> - **Your group's contributions and the contributions of the other group.**
> - Mainly your group's contributions.
> - It is randomly determined.

> Answer: The correct answer is "Your group's contributions and the contributions of the other group."

The probability of winning the prize is determined by the total contribution of the members of your group during the round, and by the total contribution of the members of the other group.
For example, if your group contributed 30 monetary units overall, while the other group contributed 70, your group will have a 30% chance of winning the prize, while the other group will have a 70%.

Control contest

What determines your chance of winning the contest?

- Your group's contributions and the contributions of the other groups.
- **Mainly your group's contributions.**
- It is randomly determined.

Answer: The correct answer is "Mainly your group's total contribution."

The probability of winning the prize is mainly determined by the total contributions of the members of your group during the round.
For example, if your group contributed 30 monetary units overall, your group will have a smaller chance of winning the prize, compared to a situation when it contributed 70 monetary units.

Question 2

High-rank players

In one round you contributed 50 of your pot of 120 monetary units, and your group wins the prize of 300 monetary units. What are your total earnings for this round, given that as a leader you earn 40% of the prize?

- 100
- 210

- **190**

Answer: The correct answer is "190".

You have 70 monetary units leftover from your pot (120 - 50) and you receive 120 monetary units from the prize (40% of 300).

Low-rank players In one round you contributed 50 of your pot of 120 monetary units, and your group wins the prize of 300 monetary units. What are your total earnings for this round, given that as a leader you earn 10% of the prize?

- **100**
- 210
- 190

Answer: The correct answer is "100".

You have 70 monetary units leftover from your pot (120 - 50) and you receive 30 monetary units from the prize (10% of 300).

Question 3

In a group penalty round, what happens at the end of the round if your group has the smallest total group contribution compared to the other groups?

- Your group has a 25% chance of being penalized.
- **Your group has a 75% chance of being penalized.**
- Your group has a 50% chance of being penalized.

Answer: The correct answer is "Your group has a 75% chance of being penalized."

In group penalty rounds, your group's total contributions will be compared

to those of the other 3 groups.

Based on the relative rank of your group, your group will be penalized with a different probability.

- If your group is 1st, you will not be penalized;
- If your group is 2nd, you will have 25% chance of being penalized;
- If your group is 3rd, you will have 50% chance of being penalized;
- If your group is 4th, you will have 75% chance of being penalized.

If your group is penalized, you and the other members of your group lose all earnings from the round.

Question 4

In a round with time constraint, how many seconds do you have to make your decision?

- 15
- 120
- **10**

Answer: The correct option is "10".

Quiz end

Now the experiment will start.

Before each round, you will find information whether the round is a group penalty round or not. Similarly, you will find information whether the round is a time constraint round or not.

Remember, in each round you are matched with 3 other players to form a

> group of 4.
>
> At any given moment, your group and 3 other groups will play the game together.
>
> In each round you will be matched only with one of the remaining 3 groups.
>
> Please, click the button and the experiment will start.

B.4.3 Round information view

Before the beginning of each round, participant saw an information view (see a sample in Figure B.3).

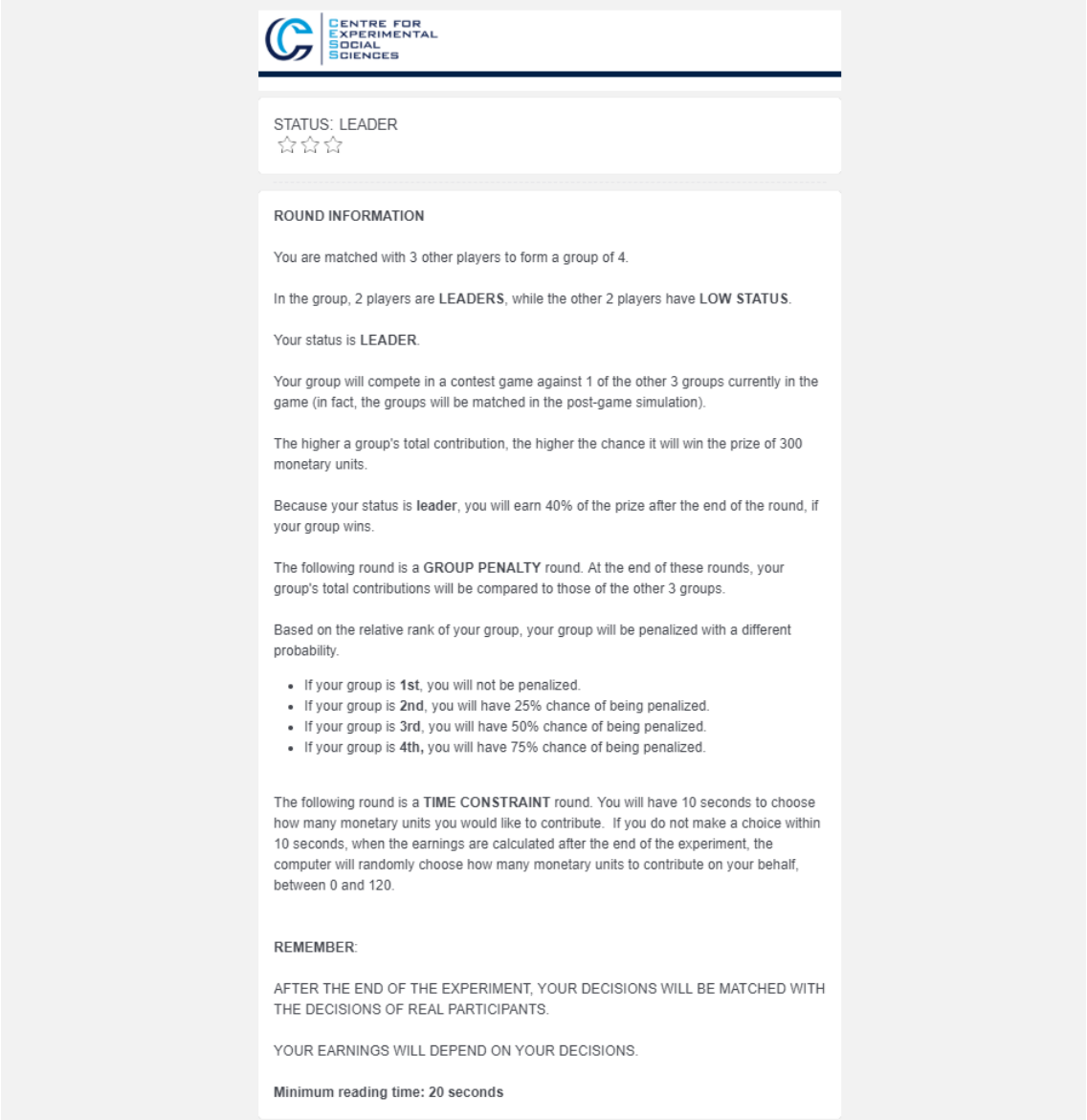


Figure B.3: Round information view for Experiment 2a

The text depended on the player type variable:

> **High-rank**
>
> Your status is LEADER.
>
> Because your status is leader, you will earn 40 of the prize after the end of the round, if your group wins.
>
> **Low-rank**
>
> Your status is LOW STATUS.
>
> Because your status is low status, you will earn 10 of the prize after the end of the round, if your group wins.

The text depended on the group penalty variable:

> **Group penalty**
>
> The following round is a GROUP PENALTY round. At the end of these rounds, your group's total contribution will be compared to those of the other 3 groups. Based on the relative rank of your group, your group will be penalized with a different probability.
>
> 1. If your group is 1st, you will not be penalized;
> 2. If your group is 2nd, you will have 25 chance of being penalized;
> 3. If your group is 3rd, you will have 50 chance of being penalized;
> 4. If your group is 4th, you will have 75 chance of being penalized.
>
> **No group penalty**
>
> The following round is NOT a GROUP PENALTY round.

The text depended on the time constraint variable:

> **Time pressure**
>
> The following round is a TIME CONSTRAINT round. You will have 10 seconds to choose how many monetary units you would like to contribute. If you do not make a choice within 10 seconds, when the earnings are calculated after the

> end of the experiment, the computer will randomly choose how many monetary units to contribute on your behalf, between 0 and 120.
>
> **Time delay**
>
> The following round is NOT a TIME CONSTRAINT round. You have to wait 10 seconds before you choose how many monetary units you would like to contribute.

The remainder of the text on the screenshot remained the same across all conditions.

B.4.4 Decision view

For each round, to make a contribution decision, participants saw a decision view (see a sample in Figure B.4).

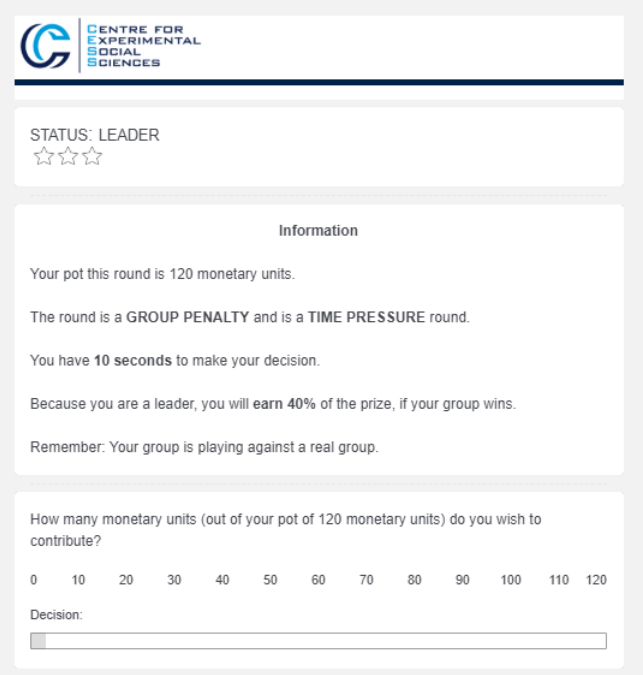


Figure B.4: Decision view for Experiment 2a

The text depended on the combination of the time constraint and group penalty variables:

> **With group penalty and with time pressure**
>
> The round is a GROUP PENALTY and is a TIME PRESSURE round.
>
> You have 10 seconds to make your decision.

> **Without group penalty and with time pressure**
>
> The round is NOT a GROUP PENALTY and is NOT a TIME PRESSURE round.
>
> **Without group penalty and with time delay**
>
> The round is NOT a GROUP PENALTY and is NOT a TIME PRESSURE round.
>
> You have to wait 10 seconds before you make your decision.
>
> **Without group penalty and with time delay**
>
> The round is a GROUP PENALTY and is NOT a TIME PRESSURE round.
>
> You have to wait 10 seconds before you make your decision.

The text depended on the player type variable:

> **High-rank**
>
> Because you are a leader, you will earn 40 of the prize, if your group wins.
>
> **Low-rank participants**
>
> Because you are with a low status, you will earn 10 of the prize, if your group wins.

The text depended on the contest type variable:

> **Inter-group contest**
>
> Remember: Your group is playing against a real group.
>
> **Control contest**
>
> NO TEXT

The remainder of the text on the screenshot remained the same across all conditions.

B.5 Models for Experiment 2a

For all models in Experiment 2a I removed the correlations between the random slopes and the interaction between the random-effects variables to simplify the structure of the model. This allowed for a successful execution without convergence errors.

B.5.1 Contribution model

```
## model specification

contribution ~ contest_type*player_type*group_penalty*constraint*gender +

    (1 + group_penalty+constraint | id)
```

Table B.1: LME model of contribution in Experiment 2a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
contest type	1.57	1, 323.08	0.211	0.004
player type	39.77	1, 323.08	< 0.001 ***	0.082
group_penalty	69.37	1, 323.49	< 0.001 ***	0.033
constraint	0.15	1, 305.84	0.697	< 0.001
gender	3.60	1, 323.08	0.059 +	0.008
contest type:player type	0.15	1, 323.08	0.695	< 0.001
contest type:group_penalty	0.18	1, 323.49	0.668	< 0.001
player type:group_penalty	1.75	1, 323.49	0.187	< 0.001
contest type:constraint	0.07	1, 305.84	0.786	< 0.001
player type:constraint	3.47	1, 305.84	0.063 +	< 0.001
group_penalty:constraint	0.07	1, 309.8	0.797	< 0.001
contest type:gender	1.79	1, 323.08	0.182	0.004
player type:gender	0.00	1, 323.08	0.962	< 0.001
group_penalty:gender	0.26	1, 323.49	0.61	< 0.001
constraint:gender	0.00	1, 305.84	0.951	< 0.001
contest type:player type:group_penalty	0.67	1, 323.49	0.414	< 0.001
contest type:player type:constraint	0.10	1, 305.84	0.758	< 0.001
contest type:group_penalty:constraint	0.74	1, 309.8	0.39	< 0.001
player type:group_penalty:constraint	6.53	1, 309.8	0.011	0.001
contest type:player type:gender	0.34	1, 323.08	0.559	< 0.001
contest type:group_penalty:gender	2.24	1, 323.49	0.135	0.001
player type:group_penalty:gender	0.00	1, 323.49	0.992	< 0.001
contest type:constraint:gender	0.03	1, 305.84	0.852	< 0.001
player type:constraint:gender	0.56	1, 305.84	0.454	< 0.001
group_penalty:constraint:gender	0.60	1, 309.8	0.437	< 0.001
contest type:player type:group_penalty:constraint	0.09	1, 309.8	0.759	< 0.001
contest type:player type:group_penalty:gender	0.06	1, 323.49	0.81	< 0.001
contest type:player type:constraint:gender	1.23	1, 305.84	0.267	< 0.001
contest type:group_penalty:constraint:gender	0.02	1, 309.8	0.876	< 0.001
player type:group_penalty:constraint:gender	0.03	1, 309.8	0.869	< 0.001
contest type:player type:group_penalty:constraint:gender	0.00	1, 309.8	0.972	< 0.001

Table B.2: EMM contrasts of contribution of player type by group penalty and contest type in Experiment 2a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	group_penalty	contest type	EMM	SE	DF	t-ratio	p	es
low-rank vs. high-rank	no_penalty	control	-20.73	5.44	323.52	-3.81	< 0.001 ***	-1.33
low-rank vs. high-rank	penalty	control	-19.16	5.53	323.95	-3.46	< 0.001 ***	-1.23
low-rank vs. high-rank	no_penalty	inter-group	-25.94	4.98	323.13	-5.21	< 0.001 ***	-1.67
low-rank vs. high-rank	penalty	inter-group	-19.24	5.06	321.92	-3.80	< 0.001 ***	-1.24

Table B.3: EMM contrasts of contribution for time constraint by group penalty and player type in Experiment 2a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	group_penalty	player type	EMM	SE	DF	t-ratio	p	es
delay vs. pressure	no_penalty	low-rank	3.42	1.73	596.39	1.98	0.049 *	0.22
delay vs. pressure	penalty	low-rank	-0.73	1.75	593.99	-0.42	0.674	-0.05
delay vs. pressure	no_penalty	high-rank	-4.59	1.89	603.90	-2.42	0.016 *	-0.30
delay vs. pressure	penalty	high-rank	0.49	1.88	594.94	0.26	0.794	0.03

Table B.4: EMM contrasts of contribution of gender by group penalty and contest type in Experiment 2a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	group_penalty	contest type	EMM	SE	DF	t-ratio	p	es
female vs. male	no_penalty	control	5.03	5.44	323.52	0.93	0.355	0.32
female vs. male	penalty	control	-1.26	5.53	323.95	-0.23	0.82	-0.08
female vs. male	no_penalty	inter-group	9.37	4.98	323.13	1.88	0.061 +	0.60
female vs. male	penalty	inter-group	12.46	5.06	321.92	2.46	0.014 *	0.80

B.5.2 Expected net benefit model

```
## model specification

expected_net_payoff ~ contest_type*player_type*group_penalty*constraint*gender +

    (1 + group_penalty+constraint | id)
```

Table B.5: LME model of expected net benefit in Experiment 2a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
contest type	0.70	1, 279.74	0.403	0.001
player type	76.09	1, 279.74	< 0.001 ***	0.138
group_penalty	913.98	1, 280.02	< 0.001 ***	0.472
constraint	0.19	1, 266.1	0.66	< 0.001
gender	2.53	1, 279.74	0.113	0.005
contest type:player type	0.15	1, 279.74	0.694	< 0.001
contest type:group_penalty	0.07	1, 280.02	0.793	< 0.001
player type:group_penalty	0.08	1, 280.02	0.78	< 0.001
contest type:constraint	0.43	1, 266.1	0.512	< 0.001
player type:constraint	5.39	1, 266.1	0.021 *	0.001
group_penalty:constraint	0.00	1, 269.99	0.963	< 0.001
contest type:gender	0.32	1, 279.74	0.573	< 0.001
player type:gender	0.00	1, 279.74	0.947	< 0.001
group_penalty:gender	3.45	1, 280.02	0.064 +	0.003
constraint:gender	0.01	1, 266.1	0.922	< 0.001
contest type:player type:group_penalty	0.23	1, 280.02	0.634	< 0.001
contest type:player type:constraint	0.16	1, 266.1	0.686	< 0.001
contest type:group_penalty:constraint	0.11	1, 269.99	0.745	< 0.001
player type:group_penalty:constraint	10.13	1, 269.99	0.002 **	0.002
contest type:player type:gender	0.30	1, 279.74	0.582	< 0.001
contest type:group_penalty:gender	0.03	1, 280.02	0.859	< 0.001
player type:group_penalty:gender	0.03	1, 280.02	0.873	< 0.001
contest type:constraint:gender	0.09	1, 266.1	0.771	< 0.001
player type:constraint:gender	0.33	1, 266.1	0.569	< 0.001
group_penalty:constraint:gender	1.27	1, 269.99	0.261	< 0.001
contest type:player type:group_penalty:constraint	0.00	1, 269.99	0.976	< 0.001
contest type:player type:group_penalty:gender	0.31	1, 280.02	0.576	< 0.001
contest type:player type:constraint:gender	0.36	1, 266.1	0.547	< 0.001
contest type:group_penalty:constraint:gender	0.10	1, 269.99	0.752	< 0.001
player type:group_penalty:constraint:gender	0.02	1, 269.99	0.892	< 0.001
contest type:player type:group_penalty:constraint:gender	0.67	1, 269.99	0.414	< 0.001

Table B.6: EMM contrasts of expected net benefit player type by contest type and group penalty in Experiment 2a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	contest type	group_penalty	EMM	SE	DF	t-ratio	p	es
low-rank vs. high-rank	inter-group	no_penalty	-22.03	4.84	280.28	-4.55	< 0.001 ***	-1.84
low-rank vs. high-rank	control	no_penalty	-18.74	5.44	279.67	-3.45	< 0.001 ***	-1.57
low-rank vs. high-rank	inter-group	penalty	-19.67	1.92	276.08	-10.25	< 0.001 ***	-1.64
low-rank vs. high-rank	control	penalty	-19.36	2.16	277.07	-8.95	< 0.001 ***	-1.62

B.6 Materials for Experiment 2b

B.6.1 Instructions

Instruction 1

You will be paid after the end of the experiment, based on your performance.

The amount you will receive depends on your decisions, so please follow ALL instructions carefully.

You will be later quizzed on your understanding of the game, so it is vital to understand its rules.

Your current decisions will be matched with the decisions of other participants in the experiment a couple of days after its end. Based on your and their performance, you will have the chance to earn monetary units which will be converted to US dollars at an exchange rate of 1 monetary unit = \$0.002 which is 100 monetary units = \$0.2.

You will receive your earnings approximately 4 weeks after the end of the session directly into your account.

You will receive your show-up fee (\$0.40) after the end of today's session and on average \$0.60 in bonus payments.

Instruction 2: Rounds

Inter-group contests The study includes 4 rounds. In each round you will have to make one decision.

In each round, your group will compete against another group in a contest game for a prize.

There are 4 groups playing at any one time (in fact, the groups will be matched in the post-game simulation).

In each round, you will play directly against only 1 of these 4 groups for the prize.

> **Control contests** The study includes 4 rounds. In each round you will have to make one decision.
>
> In each round, your group will play a game for a prize.
>
> There are 4 groups playing at any one time (in fact, the groups will be matched in the post-game simulation).

Instruction 3: Group Formation

> At the beginning of each round you are randomly matched with 3 other participants to form a group of 4 participants.
>
> After the end of each round you will be randomly matched again with 3 participants to form a new group of 4 participants.

Instruction 4: Anonymity

> The experiment is completely anonymous.
>
> The participants' identity will not be revealed, neither during nor after today's study.
>
> You will not know who your group mates are, and they will not know who you are.

Instruction 5: Your options

> You will begin each round with a "pot" of 75 monetary units.
>
> You can contribute any amount from this pot to your group's success in a contest against another group.
>
> Any amount you decide to keep will be added to your total earnings from the round.
>
> Your group mates and members of the other group will have the option to contribute to the contest in the same way as you do.

Instruction 6: The prize

> **Inter-group contests** In each round your group will be in a contest with another group for a prize of 300 monetary units.

> At the end of each round, the chance to win this prize is determined by the total contributions by members of your group, compared to the total contributions by members of the other group.
> EXAMPLE: If your group contributed 60 monetary units overall, while the other group contributed 40, your group will have a 60% chance of winning the prize, while the other group will have a 40% chance.

> **Control contests** In each round your group will play a game for a prize of 300 monetary units.
> At the end of each round, the chance to win this prize is determined by the total contributions by members of your group. The more monetary units your group contributes, the more likely it will win the prize.p
> EXAMPLE: If your group contributed 60 monetary units overall, your group will have a higher chance of winning the prize, compared to a situation when it contributed 40 monetary units.

Instruction 7: Earnings

> If your group wins the contest, the prize will be divided equally among the 4 group members.
> This means that each group member will receive 25% of the prize.

Instruction 8: Rounds with group penalty

> Rounds with group penalty
>
> Remember, the experiment has 4 rounds.
> There are 4 groups playing in any one round at the same time (in fact, the groups will be matched in the post-game simulation).
> Some rounds are group penalty rounds.
> At the end of these rounds, your group's total contributions will be compared to those of the other 3 groups.p

Based on the relative rank of your group, your group will be penalized with a different probability.

- If your group is 1st, you will not be penalized;
- If your group is 2nd, you will have 25% chance of being penalized;
- If your group is 3rd, you will have 50% chance of being penalized;
- If your group is 4th, you will have 75% chance of being penalized.

If your group is penalized, you lose all your earnings from the round. This includes:

- any "leftovers" in your pot (i.e. any amounts from your pot you did not contribute);
- any share of the prize you received.

Instruction 9: Rounds without group penalty

Other rounds are not group penalty rounds.

At the end of these rounds, groups will not be ranked and penalized.

At the beginning of each round, you will find information about whether the round is a group penalty round.

This information will be on your screen while you make your decision.

Instruction 10: Rounds with time pressure

Some rounds are time constraint rounds.

In these rounds you have 10 seconds to make your decision.

If you do not make your decision within 10 seconds, the computer will randomly "decide" your contribution for that round.

Instruction 11: Rounds without time pressure

Other rounds are not time constraint rounds.

In these rounds you have to wait 10 seconds before you make your decision.

> At the beginning of each round, you will find information about whether the round is a time constraint round. This information will be on your screen while you make your decision.

B.6.2 Quiz

Before the beginning of the actual experiment, participants filled a quiz.

Quiz instructions

> Now we will ask you questions about the rules of the game.
>
> Please, try to answer them as well as possible!
>
> After you answer each question, you will see the correct answer.

Question 1

> **Inter-group contest** What determines your chance of winning the contest?
>
> - **Your group's contributions and the contributions of the other group.**
> - Mainly your group's contributions.
> - It is randomly determined.

> Answer: The correct answer is "Your group's contributions and the contributions of the other group."
>
> The probability of winning the prize is determined by the total contribution of the members of your group during the round, and by the total contribution of the members of the other group.
>
> For example, if your group contributed 30 monetary units overall, while the other group contributed 70, your group will have a 30% chance of winning the prize, while the other group will have a 70%.

Control contest What determines your chance of winning the contest?

- Your group's contributions and the contributions of the other groups.
- **Mainly your group's contributions.**
- It is randomly determined.

Answer: The correct answer is "Mainly your group's total contribution."

The probability of winning the prize is mainly determined by the total contributions of the members of your group during the round.
For example, if your group contributed 30 monetary units overall, your group will have a smaller chance of winning the prize, compared to a situation when it contributed 70 monetary units.

Question 2

In one round you contributed 50 of your pot of 75 monetary units, and your group wins the prize of 300 monetary units. What are your total earnings for this round, given that you earn 25% of the prize?

- **100**
- 210
- 190

Answer: The correct answer is "100".

You have 25 monetary units leftover from your pot (75 - 50) and you receive 75 monetary units from the prize (25% of 300).

Question 3

In a group penalty round, what happens at the end of the round if your group has the smallest total group contribution compared to the other groups?

- Your group has a 25% chance of being penalized.

- **Your group has a 75% chance of being penalized.**
- Your group has a 50% chance of being penalized.

Answer: The correct answer is "Your group has a 75% chance of being penalized."

In group penalty rounds, your group's total contributions will be compared to those of the other 3 groups.
Based on the relative rank of your group, your group will be penalized with a different probability.

- If your group is 1st, you will not be penalized;
- If your group is 2nd, you will have 25% chance of being penalized;
- If your group is 3rd, you will have 50% chance of being penalized;
- If your group is 4th, you will have 75% chance of being penalized.

If your group is penalized, you and the other members of your group lose all earnings from the round.

Question 4

In a round with time constraint, how many seconds do you have to make your decision?

- 15
- 120
- **10**

Answer: The correct option is "10".

Experiment initiation

Now the experiment will start.

> Before each round, you will find information whether the round is a group penalty round or not. Similarly, you will find information whether the round is a time constraint round or not.
>
> Remember, in each round you are matched with 3 other players to form a group of 4.
>
> At any given moment, your group and 3 other groups will play the game together.
>
> In each round you will be matched only with one of the remaining 3 groups.
>
> Please, click the button and the experiment will start.

B.6.3 Round information view

Before the beginning of each round, participant saw an information view (see a sample in Figure B.5).

Some of the text was the same for all players in the experiment:

> You are matched with 3 other players to form a group of 4.
>
> The higher a group's total contribution, the higher the chance it will win the prize of 300 monetary units.
>
> You will earn 25% of the prize after the end of the round, if your group wins.

The text depended on the group penalty variable:

> **Group penalty**
>
> The following round is a GROUP PENALTY round. At the end of these rounds, your group's total contribution will be compared to those of the other 3 groups. Based on the relative rank of your group, your group will be penalized with a different probability.
>
> 1. If your group is 1st, you will not be penalized;
> 2. If your group is 2nd, you will have 25 chance of being penalized;
> 3. If your group is 3rd, you will have 50 chance of being penalized;
> 4. If your group is 4th, you will have 75 chance of being penalized.

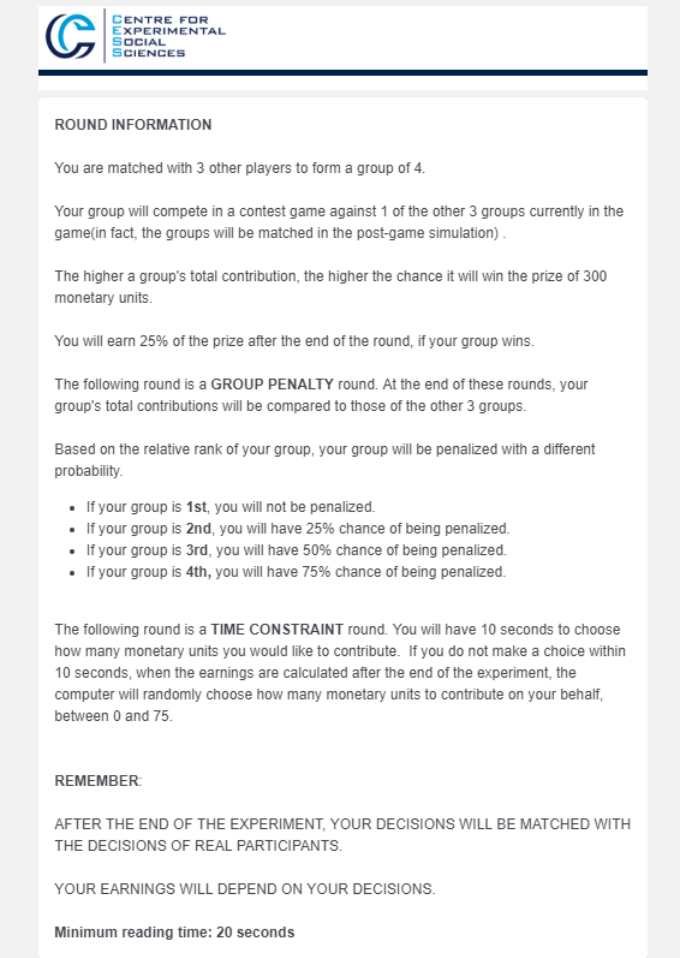


Figure B.5: Round information view for Experiment 2b

No group penalty

The following round is NOT a GROUP PENALTY round.

The text depended on the time constraint variable:

Time pressure

The following round is a TIME CONSTRAINT round. You will have 10 seconds to choose how many monetary units you would like to contribute. If you do not make a choice within 10 seconds, when the earnings are calculated after the end of the experiment, the computer will randomly choose how many monetary units to contribute on your behalf, between 0 and 120.

Time delay

> The following round is NOT a TIME CONSTRAINT round. You have to wait 10 seconds before you choose how many monetary units you would like to contribute.

The remainder of the text remained the same for all participants.

B.6.4 Decision View

For each round, to make a contribution decision, participants saw a decision view (see a sample in Figure B.6).

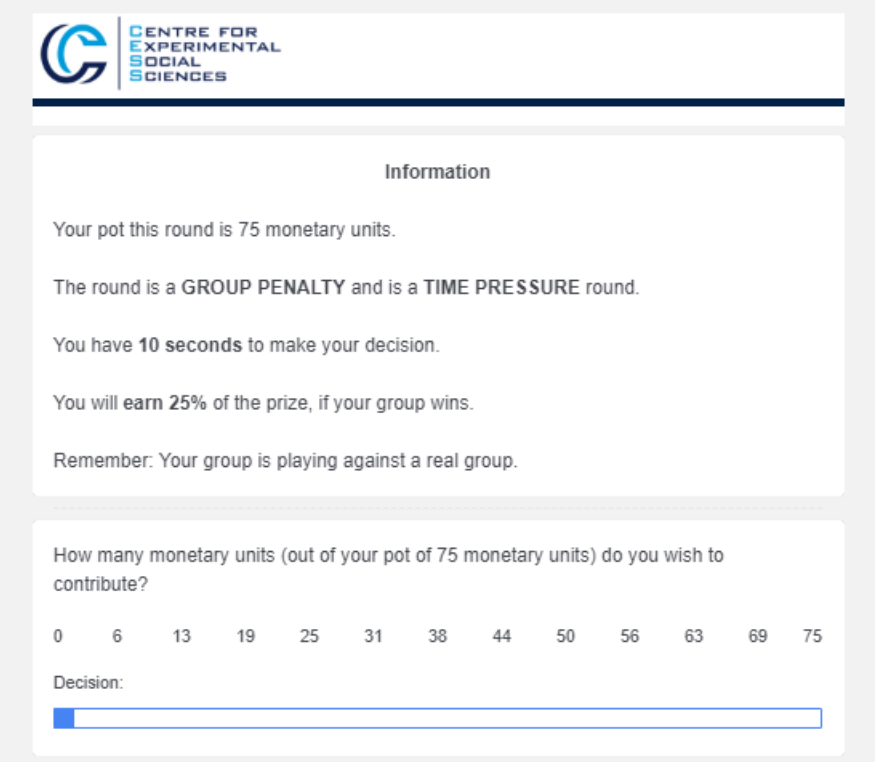


Figure B.6: Decision view for Experiment 2b

The text depended on the combination of the time constraint and group penalty variables:

> **With group penalty and with time pressure**
>
> The round is a GROUP PENALTY and is a TIME PRESSURE round.
>
> You have 10 seconds to make your decision.
>
> **Without group penalty and with time pressure**

> The round is NOT a GROUP PENALTY and is NOT a TIME PRESSURE round.
>
> **Without group penalty and with time delay**
>
> The round is NOT a GROUP PENALTY and is NOT a TIME PRESSURE round.
>
> You have to wait 10 seconds before you make your decision.
>
> **Without group penalty and with time delay**
>
> The round is a GROUP PENALTY and is NOT a TIME PRESSURE round.
>
> You have to wait 10 seconds before you make your decision.

The text depended on the contest type variable:

> **Inter-group contest**
>
> Remember: Your group is playing against a real group.
>
> **Control contest**
>
> NO TEXT

The remainder of the text remained the same for all participants:

B.7 Models for Experiment 2b

For all models in Experiment 2b I removed the correlations between the random slopes and the interaction between the random-effects variables to simplify the structure of the model. This allowed for a successful execution without convergence errors.

B.7.1 Contribution model

```
## model specification

contribution ~ contest_type*group_penalty*constraint*gender +

    (1 + group_penalty+constraint | id)
```

Table B.7: LME model of contribution in Experiment 2b Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
contest type	0.00	1, 375.64	0.956	< 0.001
group_penalty	78.96	1, 375	< 0.001 ***	0.03
constraint	1.28	1, 356.64	0.258	< 0.001
gender	2.15	1, 375.64	0.144	0.004
contest type:group_penalty	0.08	1, 375	0.78	< 0.001
contest type:constraint	0.21	1, 356.64	0.646	< 0.001
group_penalty:constraint	0.16	1, 356.43	0.694	< 0.001
contest type:gender	0.00	1, 375.64	0.944	< 0.001
group_penalty:gender	1.55	1, 375	0.214	< 0.001
constraint:gender	0.16	1, 356.64	0.686	< 0.001
contest type:group_penalty:constraint	0.02	1, 356.43	0.88	< 0.001
contest type:group_penalty:gender	1.76	1, 375	0.185	< 0.001
contest type:constraint:gender	0.04	1, 356.64	0.835	< 0.001
group_penalty:constraint:gender	2.62	1, 356.43	0.106	< 0.001
contest type:group_penalty:constraint:gender	0.01	1, 356.43	0.91	< 0.001

Table B.8: EMM contrasts of contribution for gender by group penalty and contest type in Experiment 2b. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	group_penalty	contest type	EMM	SE	DF	t-ratio	p	es
female vs. male	no_penalty	control	3.11	3.36	376.30	0.93	0.355	0.32
female vs. male	penalty	control	3.26	3.17	375.45	1.03	0.305	0.34
female vs. male	no_penalty	inter-group	5.25	3.24	375.04	1.62	0.106	0.55
female vs. male	penalty	inter-group	0.54	3.06	375.31	0.18	0.859	0.06

B.8 Models for the group comparison in Study 2

B.8.1 Contribution model

Table B.9: ANOVA model of relative total contribution in Study 1. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Pes
contest type	0.56	1, 160	0.454	0.004
system type	50.74	1, 160	< 0.001 ***	0.241
contest type:system type	1.00	1, 160	0.318	0.006
constraint	0.04	1, 160	0.833	< 0.001
contest type:constraint	0.05	1, 160	0.816	< 0.001
system type:constraint	0.02	1, 160	0.894	< 0.001
contest type:system type:constraint	0.00	1, 160	0.959	< 0.001
group_penalty	93.43	1, 160	< 0.001 ***	0.369
contest type:group_penalty	0.58	1, 160	0.447	0.004
system type:group_penalty	0.02	1, 160	0.887	< 0.001
contest type:system type:group_penalty	0.83	1, 160	0.363	0.005
constraint:group_penalty	0.22	1, 160	0.643	0.001
contest type:constraint:group_penalty	0.05	1, 160	0.825	< 0.001
system type:constraint:group_penalty	0.04	1, 160	0.846	< 0.001
contest type:system type:constraint:group_penalty	0.05	1, 160	0.825	< 0.001

Table B.10: EMM contrasts of relative total contribution for system type by contest type and group penalty in Study 2. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	contest type	group_penalty	EMM	SE	DF	t-ratio	p	es
hierarchy vs. egalitarianism	inter-group	no_penalty	-8.66	2.57	286.95	-3.37	< 0.001 ***	-0.57
hierarchy vs. egalitarianism	control	no_penalty	-13.76	2.79	286.95	-4.93	< 0.001 ***	-0.91
hierarchy vs. egalitarianism	inter-group	penalty	-10.34	2.57	286.95	-4.02	< 0.001 ***	-0.69
hierarchy vs. egalitarianism	control	penalty	-11.46	2.79	286.95	-4.11	< 0.001 ***	-0.76

C

Study 3

C.1 Methods

Both experiments in Study 3 were executed online with a sample of Mechanical Turk participants. The first experiment (Experiment 3a) was executed asynchronously. In this study each participant just made decisions in hypothetical situations and did not receive feedback about his/her earnings or group performance. The second experiment (Study 3b) was executed synchronously, as participants made their decisions and received feedback about their performance soon after.

Procedure Participants in both studies read information sheets, signed consent forms, read instructions, and played the experimental game a number of times.

Contest game This experiment again used the two-group contest game as a main paradigm, as in Study 1 and Study 2. Participants were divided into groups of three individuals and each group was randomly matched with another group to play for a prize. Group members were asked to make a contribution decision, which is a proxy measurement of their effort. The sum of these contribution decisions is the total contribution of participants. The group with a higher total contribution received a higher probability to win a prize from the contest.

Hierarchy and power In both experiments participants played in hierarchical groups with high- and low-power players. Hierarchy in this case was defined in a political way, based on the power of one individual to influence the decisions of another individual. Thus, high-power individuals had influence over the decisions of the low-power individuals. The low-power individuals, on the other hand, had to contribute to increase the probability of their group to win the prize in the contest. Moreover, they were asked whether they want to pay a number of points to resist the power of the high-power individuals, which is indicative of their resistance preferences.

Manipulations In Experiment 3a I manipulated whether participants played inter-group contests or control contests, as manipulated in Study 1 and Study 2. In inter-group contests participants played in groups against another group in a minimal groups settings. In control contests, participants played against the experimental software. Furthermore, in this experiment I manipulated whether the high-power player in the group earns more or less than the low-power players after each contest. This allowed me to assess whether there was an interaction between political and economic hierarchy — e.g. whether players were more resistant toward political hierarchy only when the high-power players earn more. Furthermore, it allowed me to see whether economic inequality was detrimental for the contribution

preferences of players.

In Experiment 3b I manipulated the difficulty of the inter-group contest. All participants played only inter-group contests. However, when groups were matched against other groups, some groups received a bonus toward their total contribution, while other groups did not receive such bonus. By design, the groups with a bonus were more likely to win the contest. In both experiments I manipulated the time constraint for each decision. Some participants made their decisions under time pressure, while other participants made their decisions under time delay.

Payments In both experiments participants were paid a show-up fee and a bonus. In Experiment 3a participants were paid a show-up fee of \$0.6 and a fixed bonus of \$0.4. In Experiment 3b participants were paid a \$1.5 show-up fee. Furthermore, each participant received a bonus of \$1 on average, based on her/his performance during the game. Within Experiment 3b participants earned points, which were converted to US dollars at an exchange rate of 1 point = \$0.00187.

Ethics Study 3 was approved by the Departmental Research Ethics Committee, School of Anthropology and Museum Ethnography, University of Oxford.

Measurements to minimize inattention in Experiment 3b In Experiment 3b, participants were invited through the Amazon's Mechanical Turk service in an entry survey, which introduced them to the experiment's requirements. Furthermore, they were asked to be attentive during the experiment. After the entry survey, participants were invited to the experimental platform in batches of six players. All players currently in the session were further split into two groups of three players at the beginning of the experimental game.

Each round began when all participants were ready with their decisions. Thus, if one participant was inattentive during the experimental procedure, all other participants had to wait for her/his decision. In other words, the pace of the

experiment depended on the slowest participant. To minimize this problem, I introduced maximum reading time for all pages in the study, which was proportional to the amount of text in the page. If a participant was not able to go to the next page in the allocated time, s/he was flagged as inattentive and was replaced by a bot. Each bot was making the decisions of the dropped-out player at random, following a uniform distribution. This technique has been used previously by other researchers (see Suri and Watts (2011) for an example).

C.2 Analytical framework

To analyze the results I used linear mixed effects (LME) models, as in all previous experiments. For each model, I constructed an iteration with the maximal random structure, as justified by the experimental design (Barr et al., 2013; Singmann & Kellen, 2017). Thus, the slopes and intercepts of all within-subject variables, together with all possible interactions, were nested in the participant variable. If the model had convergence issues, I simplified the random structure by removing the interactions between the random-effects variables. For all models I used a set of estimated marginal means (EMM) contrast comparisons (R. V. Lenth et al., 2016) to explore significant interactions and hypothesized cell-level differences.

C.3 Materials for Experiment 3a

C.3.1 Instructions

Instruction 1: Reading time

> For each important page in the instructions you will have a pre-determined minimum reading time.
> You can click the button to proceed to the next page only when this time is expire.d

Instruction 2

> You will be paid after the end of the experiment, based on your performance.
> The amount you will receive depends on your decisions, so please follow ALL instructions carefully.
> You will be later quizzed on your understanding of the game, so it is vital to understand its rules.
> Your current decisions will be matched with the decisions of other participants in the experiment a couple of days after its end. Based on your and their performance, you will have the chance to earn points which will be converted to US dollars at an exchange rate of 1 point = $0.0005.
> You will receive your earnings directly into your account approximately 1 week after the end of the session.
> You will receive your show-up fee ($0.60) after the end of today's session and on average $0.40 in bonus payments, based on the number of points you have collected.
> Minimum reading time: 9 seconds

Instruction 3: Anonymity

> The experiment is completely anonymous.
>
> All participants are online users and their identity will not be revealed, neither during nor after today's experiment, as it is not known by the researchers.
> You will not know who the other participants are and they will not know who you are.
> Minimum reading time: 6 seconds

Instruction 4: Group Formation

> **Inter-group contests** The study includes 4 rounds.
>
> At the beginning of each round you are randomly matched with 2 other participants to form a group of 4 participants.
> In each round, your group will compete against one randomly selected group in a game for a prize.
> Minimum reading time: 6 seconds

> **Control contests** The study includes 4 rounds.
>
> At the beginning of each round you are randomly matched with 2 other participants to form a group of 4 participants.
> In each round, your group will play a game for a prize.
> Minimum reading time: 6 seconds

Instruction 5: Roles

> There are two roles in the game: high-power players and low-power players.
>
> In each group of 3 players, 1 player will have high power, while the other 2 players will have low power.
> The high-power player will have the ability to change the decisions of the 2 low-power players in the group.
> The low-power players will have to make contributions toward the group's success in the game against another group for a prize. They will also have the ability

to pay in order to resist the high-power player.

You will be randomly assigned to one role at the beginning of the game.

Minimum reading time: 16 seconds

Instruction 6: The Game

Inter-group contests Remember, in each round your group will compete against another group in a game for a prize.

The prize will be 600 points.

You will play 4 rounds of the game.

The chance of winning the prize is determined by the total contribution made by the low-power players in your group compared to the total contribution made by the low-power players in the other group.

The total contribution is the sum of the contributions made by the 2 low-power players.

Example: For example, if the low-power players in your group contributed 60 points in total, while the low-power players in the other group contributed 40 points in total, your group will have a 60% chance of winning the prize, while the other group will have a 40% chance.

Minimum reading time: 16 seconds

Control contests Remember, in each round your group will play a game for a prize.

The prize will be 600 points.

You will play 4 rounds of the game.

The chance of winning the prize is determined by the total contribution made by the low-power players in your group.

The total contribution is the sum of the contributions made by the 2 low-power players.

> Example: For example, if the low-power players in your group contributed 60 points in total, your group will have a higher chance of winning the prize, compared to a situation when they contributed 40 monetary units.
> Minimum reading time: 16 seconds

Instruction 7: Earnings

> If your group wins the prize, the prize will be divided equally among all group members, including the high-power player. This means that each group member will receive 200 points from the prize of 600 points.
> Minimum reading time: 6 seconds

Instruction 8: Rounds with a bonus for the high-power player

> In some rounds, if your group wins the prize, the high-power player in your group will receive a bonus of 200 points on top of his/her baseline earnings of 200 points from the prize.
> Thus, s/he will earn 400 points in total.
> If your group does not win the prize, s/he will earn 0 points from the prize, like all other players.
> Minimum reading time: 9 seconds

Instruction 9: Rounds without a bonus for the high-power player

> In other rounds, the high-power player will not receive a bonus. Thus, s/he will earn 200 points from the prize, like all other players.
> At the beginning of each round, you will find information about whether the round is with or without a bonus for the high-power player. This information will be on your screen while you make your decisions.
> Minimum reading time: 6 seconds

Instruction 10: Rounds with time pressure

> Some rounds are time pressure rounds.
>
> In these rounds you have 10 seconds to make each of your decisions.
>
> Minimum reading time: 6 seconds

Instruction 11: Rounds with time delay

> Other rounds are time delay rounds.
>
> In these rounds you have to wait 15 seconds before you make each of your decisions.
>
> At the beginning of each round, you will find information about whether the round is a time pressure or a time delay round. This information will be on your screen while you make your decisions.
>
> Minimum reading time: 6 seconds

Instruction 12: Assignment

> Now you will be assigned a role in the game.
>
> You will be randomly assigned to be either a high-power or a low-power player.
>
> ...
>
> You have been assigned to be a LOW-POWER PLAYER.
>
> You will keep your role until the end of the game (4 rounds).

Instruction 13: Your pots

> As a low-power player, you will begin each of the 4 rounds with two pots of 100 points each: the contribution pot and the resistance pot.
>
> You will be able to make a contribution and a resistance decision with your pots.
>
> Minimum reading time: 6 seconds

Instruction 14: Contribution decision

> You can contribute any number of points from your contribution pot to your group's total contribution.

Remember, your group's total contribution affects your group's success in the game against the other group. The higher your group's total contribution, the higher its chances of winning the prize of 600 points.

Any unused points from the contribution pot will be added to your total earnings from the round.

Minimum reading time: 9 seconds

Instruction 15: Resistance decision

You can use any number of points from your resistance pot to resist the ability of the high-power player in your group to change your decision.

The high-power player will be given the ability to make a decision about the preferred amount of points you will contribute towards your group's total contribution.

The number of points you use from your resistance pot affects how much of your final contribution is determined by you and how much is determined by the high-power player.

The more points you use toward your resistance decision, the more you will reduce his/her ability to change your preferred contribution.

Example: Imagine a situation where you prefer to contribute 50 points from your contribution pot, whereas the high-power player in your group decides that you contribute 100 points:

- If you use 100 points from your resistance pot, you will control 100% of your decision. In this scenario, you will contribute your preferred amount of 50 points;
- If you use 50 points from your resistance pot, you will control 50% of your decision, and the other 50% will be controlled by the high-power player. In this scenario, you will actually contribute 75 points;
- If you use 0 points from your resistance pot, you will control 0% of your

decision. In this scenario, you will actually contribute 100 points.

Any unused points from the resistance pot will be added to your total earnings from the round.

Minimum reading time: 20 seconds

Instruction 16: A short summary

Inter-group contests In each round, you will be assigned to a group of 3 players (including you).

In each group, 1 player will have high power, while the other 2 players will have low power. High-power players will have the ability to change the contributions of players with low power; Low-power players, like you, will be asked to contribute to the group's success with their contribution pot and resist the power of the high-power player with their resistance pot. As a low-power player, the more points you use from your resistance pot, the more control you will have over your final contribution. Any unused points from your contribution and resistance pots will be added to your total earnings from each round.

Your group will be playing the game with another group for a prize of 600 points. The group whose low-power players contribute more will have a higher chance of winning the prize. Thus, as a low-power player, the more points you use from your contribution pot, the higher the probability of your group winning the prize.

In some rounds the high-power player in your group will receive a bonus of 200 points if your group wins the prize, while in other rounds s/he will not receive a bonus.

Finally, in some rounds you will have 10 seconds to make each of your decisions, while in others you will have to wait 15 seconds before you can make each of your decisions.

Minimum reading time: 20 seconds

Control contests In each round, you will be assigned to a group of 3 players (including you).

In each group, 1 player will have high power, while the other 2 players will have low power. High-power players will have the ability to change the contributions of players with low power; Low-power players, like you, will be asked to contribute to the group's success with their contribution pot and resist the power of the high-power player with their resistance pot. As a low-power player, the more points you use from your resistance pot, the more control you will have over your final contribution. Any unused points from your contribution and resistance pots will be added to your total earnings from each round.

Your group will be playing the game for a prize of 600 points. The more monetary units the low-power players in your group contribute, the more likely it will win the prize. Thus, as a low-power player, the more points you use from your contribution pot, the higher the probability of your group winning the prize.

In some rounds the high-power player in your group will receive a bonus of 200 points if your group wins the prize, while in other rounds s/he will not receive a bonus.

Finally, in some rounds you will have 10 seconds to make each of your decisions, while in others you will have to wait 15 seconds before you can make each of your decisions.

Minimum reading time: 20 seconds

C.3.2 Quiz

Before the beginning of the actual experiment, participants filled a short quiz.

Quiz: Introduction

Now we will ask you questions about the rules of the game.

Please, try to answer them as well as possible!

After you answer each question, you will see the correct answer.

Question 1

Inter-group contests Question 1: What determines your chance of winning the contest?

- Your group's total contribution and the total contribution of the other group.
- Mainly your group's total contribution.
- It is randomly determined.

Answer: The correct answer is "Your group's total contribution and the total contribution of the other group."

The probability of winning the prize is determined by the total contribution of the members of your group during the round, and by the total contribution of the members of the other group.

For example, if your group contributed 30 points overall, while the other group contributed 70, your group will have a 30% chance of winning the prize, while the other group will have a 70% chance.

Control contests Question 1: What determines your chance of winning the contest?

- Your group's total contribution and the total contribution of the other group.
- Mainly your group's total contribution.
- It is randomly determined.

Answer: The correct answer is "Mainly your group's total contribution."

The probability of winning the prize is mainly determined by the total contribution of your group during the round.

> For example, if the low-power players in your group contributed 30 points in total, your group will have a lower chance of winning the prize, compared to a situation when they contributed 70 monetary units.

Question 2

> Question 2: How much will the bonus of the high-power player be, if s/he is to receive it?
>
> - 150 points
> - 200 points
> - 400 points

> Answer: The correct answer is "200 points".
>
> In rounds with a bonus for the high-power player, s/he will receive a bonus of 200 points on top of his/her baseline earnings of 200 points. Thus, s/he will earn 400 points if the group wins the prize.

Question 3

> Question 3: In a round with time pressure, how many seconds do you have to make your decision?
>
> - 15 seconds
> - 120 seconds
> - 10 seconds

> Answer: The correct answer is "10 seconds".
>
> With time pressure, you have 10 seconds to make your decision.

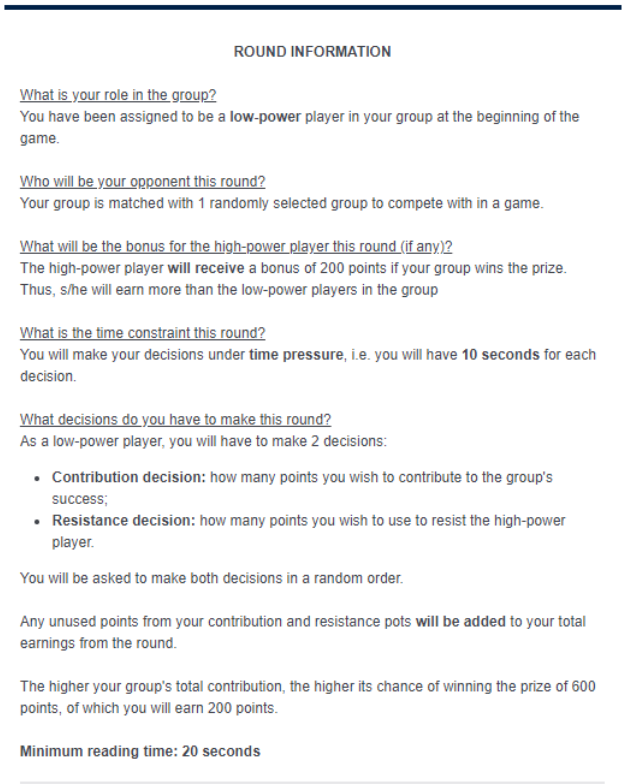
Experiment initiation

> Now the experiment will start.
>
> You will play 4 rounds of the game.
>
> Before each round, you will see information about the round.

> Remember, in each round you are assigned with 2 other players to form a group of 3.
>
> Furthermore, in each round your group will be matched with 1 randomly selected group to compete for a prize of 600 points.
>
> Please, click the button and the experiment will start.

C.3.3 Round information view

Before each round, players saw a round information view (see a sample in Figure C.1).



ROUND INFORMATION

What is your role in the group?
You have been assigned to be a **low-power** player in your group at the beginning of the game.

Who will be your opponent this round?
Your group is matched with 1 randomly selected group to compete with in a game.

What will be the bonus for the high-power player this round (if any)?
The high-power player **will receive** a bonus of 200 points if your group wins the prize. Thus, s/he will earn more than the low-power players in the group

What is the time constraint this round?
You will make your decisions under **time pressure**, i.e. you will have **10 seconds** for each decision.

What decisions do you have to make this round?
As a low-power player, you will have to make 2 decisions:

- **Contribution decision:** how many points you wish to contribute to the group's success;
- **Resistance decision:** how many points you wish to use to resist the high-power player.

You will be asked to make both decisions in a random order.

Any unused points from your contribution and resistance pots **will be added** to your total earnings from the round.

The higher your group's total contribution, the higher its chance of winning the prize of 600 points, of which you will earn 200 points.

Minimum reading time: 20 seconds

Figure C.1: Round information view for Experiment 3a

The text depended on the economic system type condition:

> **Economic hierarchy**
>
> What will be the bonus for the high-power player this round (if any)?
>
> The high-power player will receive a bonus of 200 points if your group wins the prize. Thus, s/he will earn more than the low-power players in the group

> **Economic egalitarianism** What will be the bonus for the high-power player this round (if any)?
>
> The high-power player will NOT receive a bonus of 200 points if your group wins the prize. Thus, s/he will earn as much as the low-power players in the group.

The text depended on the time constraint variable:

> **Time pressure** What is the time constraint this round?
>
> You will make your decisions under time pressure, i.e. you will have 10 seconds for each decision.
>
> **Time delay** What is the time constraint this round?
>
> You will make your decisions under time delay, i.e. you will have to wait 15 seconds before you can make each decision.

The remainder of the text on the screenshot remained the same across all conditions, as all players were assigned a low-power role.

C.3.4 Decision views

Contribution decision

In each round, players had to make a contribution decision (see a sample in Figure C.2).

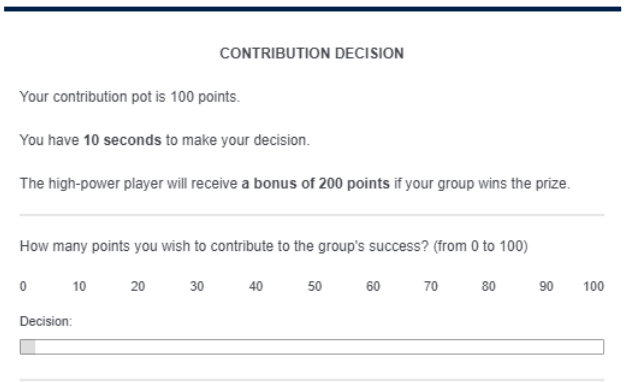


Figure C.2: Contribution decision view for Experiment 3a

The text depended on the time constraint condition:

> **Time pressure**
>
> You have 10 seconds to make your decision.
>
> **Time delay**
>
> You have to wait 15 seconds before you can make your decision.

The text depended on the economic system type condition:

> **Economic hierarchy**
>
> The high-power player will receive a bonus of 200 points if your group wins the prize.
>
> **Economic egalitarianism**
>
> The high-power player will NOT receive a bonus of 200 points if your group wins the prize.

The remainder of the text on the screenshot remained the same across all conditions.

Resistance decision

In each round, players also had to make a contribution decision (see a sample in Figure C.3).

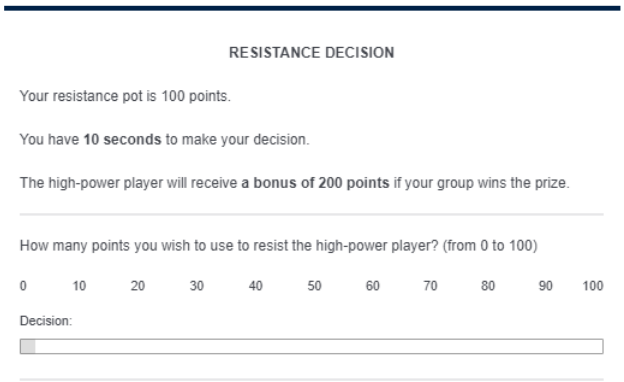


Figure C.3: Resistance decision view for Experiment 3a

The text depended on the time constraint condition:

> **Time pressure**
>
> You have 10 seconds to make your decision.

> **Time delay**
>
> You have to wait 15 seconds before you can make your decision.

The text depended on the economic system type condition:

> **Economic hierarchy**
>
> The high-power player will receive a bonus of 200 points if your group wins the prize.
>
> **Economic egalitarianism**
>
> The high-power player will NOT receive a bonus of 200 points if your group wins the prize.

The remainder of the text on the screenshot remained the same across all conditions.

C.4 Models for Experiment 3a

For all models in Experiment 3a I removed the correlations between the random slopes and the interaction between the random-effects variables to simplify the structure of the model. This allowed for a successful execution without convergence errors.

C.4.1 Contribution model

```
## model specification

contribution ~ contest_type*constraint*economic_system*gender +

    (1 + constraint+economic_system | id)
```

Table C.1: LME model of contribution in Experiment 3a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
contest type	0.10	1, 345.92	0.758	< 0.001
constraint	0.02	1, 342.84	0.901	< 0.001
economic system	0.46	1, 344.95	0.499	< 0.001
gender	0.33	1, 345.92	0.564	< 0.001
contest type:constraint	0.33	1, 342.84	0.566	< 0.001
contest type:economic system	0.56	1, 344.95	0.455	< 0.001
constraint:economic system	0.01	1, 343.74	0.921	< 0.001
contest type:gender	0.00	1, 345.92	0.971	< 0.001
constraint:gender	0.03	1, 342.84	0.869	< 0.001
economic system:gender	0.59	1, 344.95	0.443	< 0.001
contest type:constraint:economic system	0.03	1, 343.74	0.866	< 0.001
contest type:constraint:gender	0.26	1, 342.84	0.612	< 0.001
contest type:economic system:gender	0.05	1, 344.95	0.832	< 0.001
constraint:economic system:gender	0.96	1, 343.74	0.328	< 0.001
contest type:constraint:economic system:gender	12.28	1, 343.74	< 0.001 ***	0.003

Table C.2: EMM contrasts of contribution for economic system type by the interaction of all other variables in Experiment 3a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	gender	contest type	constraint	EMM	SE	DF	t-ratio	p	es
equality vs. inequality	female	control	delay	-3.20	2.87	655.96	-1.12	0.265	-0.19
equality vs. inequality	male	control	delay	3.53	2.87	655.96	1.23	0.219	0.21
equality vs. inequality	female	inter-group	delay	4.95	2.98	655.96	1.66	0.097 +	0.30
equality vs. inequality	male	inter-group	delay	-1.93	2.63	655.96	-0.73	0.463	-0.12
equality vs. inequality	female	control	pressure	0.88	2.90	661.05	0.30	0.762	0.05
equality vs. inequality	male	control	pressure	-1.52	2.89	661.18	-0.53	0.599	-0.09
equality vs. inequality	female	inter-group	pressure	-3.03	3.01	669.01	-1.01	0.314	-0.18
equality vs. inequality	male	inter-group	pressure	6.30	2.67	673.15	2.36	0.019 *	0.38

C.4.2 Resistance model

```
## model specification

resistance ~ contest_type*constraint*economic_system*gender +

    (1 + economic_system+constraint | id)
```

Table C.3: LME model of resistance in Experiment 3a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
contest type	0.49	1, 345.87	0.483	0.001
constraint	0.00	1, 340.79	0.994	< 0.001
economic system	3.07	1, 344.6	0.081 +	0.001
gender	2.42	1, 345.87	0.121	0.005
contest type:constraint	0.11	1, 340.79	0.737	< 0.001
contest type:economic system	0.02	1, 344.6	0.896	< 0.001
constraint:economic system	1.49	1, 342.52	0.223	< 0.001
contest type:gender	0.03	1, 345.87	0.858	< 0.001
constraint:gender	0.03	1, 340.79	0.855	< 0.001
economic system:gender	1.87	1, 344.6	0.173	< 0.001
contest type:constraint:economic system	1.99	1, 342.52	0.159	< 0.001
contest type:constraint:gender	0.15	1, 340.79	0.702	< 0.001
contest type:economic system:gender	1.94	1, 344.6	0.164	< 0.001
constraint:economic system:gender	0.42	1, 342.52	0.515	< 0.001
contest type:constraint:economic system:gender	0.14	1, 342.52	0.706	< 0.001

Table C.4: EMM contrasts of resistance for economic type by time constraint in Experiment 3a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	constraint	EMM	SE	DF	t-ratio	p	es
equality vs. inequality	delay	-1.03	1.70	645.32	-0.61	0.544	-0.05
equality vs. inequality	pressure	-3.66	1.73	661.96	-2.11	0.035 *	-0.18

C.5 Materials for Experiment 3b

C.5.1 Instructions

Instruction 1

> Welcome!
>
> You are about to take part in a decision-making experiment.
>
> There are 6 players in this experiment.
>
> During the experiment, you will read instructions and play 4 rounds of a game.
>
> Like you, all players are Mechanical Turk users.
>
> Your progress in the study will depend on the progress of all other players, so you will have to wait for their decisions.
>
> The amount you will receive depends on your decisions, so please follow the instructions carefully!
>
> You will have a limited time to read each page. After this time has elapsed, the page will be auto-submitted, and you will be flagged as inattentive.

Instruction 2: Earnings

> You will be paid at the end of the experiment via your Mechanical Turk account.
>
> During the experiment you will have the chance to earn points, which will be converted into U.S. dollars.
>
> The exchange rate is 1 point = \$0.00187

Instruction 3: Rounds and Groups

> In this experiment you will play 4 rounds of a decision-making game.
>
> There will be 2 groups playing the game simultaneously.
>
> Because the game is played simultaneously, in some instances you will have to wait for all other players to arrive at the same page.

> At the beginning of the game, you will be randomly allocated to one of the 2 groups, so that each group includes 3 players.
> In each round, your group will compete against the other group in a game for a prize. More information about the game and the prize will be given later.

Instruction 4: Anonymity

> The experiment is completely anonymous.
>
> All participants are online users and their identity will not be revealed, neither during nor after today's experiment, as it is not known by the researchers. You will not know who your group mates are, and they will not know who you are.

Instruction 5: Roles

> There are two roles in the game: high-power players and low-power players.
>
> In each group of 3 players, 1 player will have high power, while the other 2 players will have low power.
> The high-power player will have the power to influence the decisions of the 2 low-power players in the group.
> Low-power players will have to make contributions toward the group's success in the game for a prize. They will also have the ability to pay in order to resist the power of the high-power player.
> You will be randomly assigned to 1 of the 2 roles at the beginning of the game.

Instruction 6: Game and Prize

> In each round, your group will be playing a game with the other group for a prize of 600 points.
> The chance of winning the prize is determined by the total contributions by the low-power players in your group compared to the total contributions by the low-power players in the other group.

Instruction 7: Options: High-Power Players

Your options in the game will depend on your role in the game.

If you are a high-power player, you are given the power to make a decision about the preferred amount of points the 2 low-power players will contribute towards your group's total contributions.

Your decision may influence the contributions of the 2 low-power players. In turn, this affects your group's success in the game against the other group.

As a high-power player, you will automatically earn 200 points from each round!

Instruction 8: Options: Low-Power Players

If you are a low-power player, you will begin each round with two "pots" of 100 points each: the "contributions" pot and the "resistance" pot.

Contributions

You can contribute any number of points from your "contributions" pot to your group's total contributions. Remember, your group's total contributions affects your group's success in the game against the other group.

Resistance

You can use any number of points from your "resistance" pot to resist the power of the high-power player in your group. The more points you use, the more you will reduce his/her influence over your preferred contribution.

The number of points you use from your "resistance" pot affects how much of your final contribution is determined by you.

Examples:

Imagine a situation where you prefer to contribute 50 points from your "contributions" pot, whereas the high-power player in your group prefers that you contribute 100 points:

- If you use 100 points from your "resistance" pot, you will control 100preferred amount of 50 points.

- If you use 50 points from your "resistance" pot, you will control 50controlled by the high-power player. In this scenario, you will actually contribute 75 points.
- If you use 0 points from your "resistance" pot, you will control 0actually contribute 100 points.

Any unused points from the two pots will be added to your total earnings from the round.

Instruction 9: Prize

Remember, the chance to win the prize of 600 points is determined by the total contributions of the low-power players in your group compared to the total contributions of the low-power players in the other group.

Example:

For example, if the low-power players in your group contributed 60 points overall, while the low-power players in the other group contributed 40, your group will have a 60prize, while the other group will have a 40

If your group wins the prize, the prize will be divided equally among all group members, including the high-power player. This means that each group member will receive 200 points from the prize of 600 points.

To summarize, your final earnings from each round will depend on your role and on whether your group wins the prize.

- If you are a high-power player, you will earn 200 guaranteed points plus 200 points from the prize, if your group has won.
- If you are a low-power player, you will keep any unused points from your "contribution" and "resistance" pots, plus 200 points from the prize, if your group has won.

Instruction 10: Advantage and Disadvantage

In each round, one group will be in an advantageous position and the other in a disadvantageous position.

Group advantage

In some rounds, your group will be in an advantageous position in comparison to the other group.

This means that the number of points contributed by the low-power players will be increased by 40%.

For example, if the final contribution of a low-power player is 50 points, he/she will actually contribute 60 points, but only 50 points will be deducted from his/her "contributions" pot.

Thus, in rounds where your group is in an advantageous position, the group will need to contribute relatively less overall to win the prize.

Group disadvantage

In other rounds, your group will be in a disadvantageous position in comparison to the other group.

This means that the number of points contributed by the low-power players will be decreased by 40%.

For example, if the final contribution of a low-power player is 50 points, he/she will actually contribute 40 points, despite the fact that 50 points are deducted from his/her "contributions" pot.

In rounds where your group is in a disadvantageous position, the group will need to contribute relatively more overall to win the prize.

At the beginning of each round you will find information about whether your group is in an advantageous or in a disadvantageous position.

Instruction 11: Time Constraint

Rounds with time pressure Some rounds are time pressure rounds.

In these rounds you have 10 seconds to make your decision.

If you do not make your decision within 10 seconds, the computer will randomly make your decision.

Rounds with time delay Other rounds are time delay rounds. In these rounds you have to wait 15 seconds before you can make your decision.

At the beginning of each round, you will find information about whether the round is a time pressure or a time delay round. This information will be on your screen while you make your decision.

Instruction 12: Summary

A short summary

- You will be assigned to a group of 3 players (including you) at the beginning of the game;
- In each group 1 player will have high power, while the other 2 players will have low power.
- High-power players will have the power to influence the contributions of players with low power.
- Low-power player will be able to contribute to the group's success with their "contributions" pot and resist the power from the high-power player with their "resistance" pot. As a low-power player, the more points you use from your "resistance" pot, the more you control your final contribution.
- Your group will be playing the game with another group for a prize of 600 points. The group whose low-power players contribute more will have a higher chance of winning the prize.
- In some rounds your group will be in an advantageous position, and the

final contributions of the low-power players will be increased by 40%. In other rounds your group will be in a disadvantageous position, and the final contributions of the low-power players will be decreased by 40%.

- Moreover, in some rounds you will have 10 seconds to make your decision, while in others you will have to wait 15 seconds before you can make your decision.

Remember:

Because the game is executed simultaneously, in some instances you will have to wait for all players to arrive at the same page.

Instruction 13: Assignment

High-power players YOU HAVE BEEN RANDOMLY ASSIGNED TO BE A HIGH-POWER PLAYER IN THIS GAME.

As a high-power player, you will be able to use your power to decide how many points (if any) you prefer the 2 low-power players in your group to contribute toward your group's success.

You will keep your role until the end of the game (4 rounds).

Press the button to start the actual game.

Low-power players YOU HAVE BEEN RANDOMLY ASSIGNED TO BE A LOW-POWER PLAYER IN THIS GAME.

As a low-power player, you will make two important decisions:

- how many points (if any) you wish to contribute to the group's success in the game;
- how many points (if any) you wish to use to resist the power of the high-power player over your contribution.

You will keep your role until the end of the game (4 rounds).

Press the button to start the actual game.

C.5.2 Round information view

Before each round, players saw a round information view (see a sample in Figure C.4).

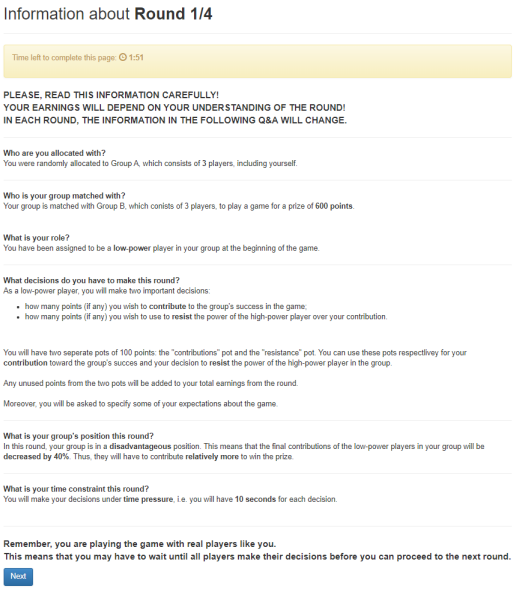


Figure C.4: Round information view for Experiment 3b

Some of the instructions depended on the round number.

> **During first round**
>
> Who are you allocated with?
>
> You were randomly allocated to Group A, which consists of 3 payers including yourself.
>
> Who is your group matched with?
>
> Your group is matched with Group B, which consists of X players, to play a game for a prize of 600 points.
>
> **During all other rounds**
>
> You are allocated to the same group (Group A), which consists of 3 players, including yourself.
>
> Who is your group matched with?
>
> Your group is matched with the same group (Group B), which consists of 3

players, to play a game for a prize of 600 points.

Some of the text was the same for the type of player:

High-power players

What is your role?

You have been assigned to be a high-power player in your group at the beginning of the game.

What decisions do you have to make this round?

As a high-power player, you will be able to use your power to decide how many points (if any) you prefer the 2 low-power players in your group to contribute toward your group's success. You will earn guaranteed 200 points from this round.

Low-power players

What is your role?

You have been assigned to be a low-power player in your group at the beginning of the game.

What decisions do you have to make this round?

As a low-power player, you will make two important decisions:

- how many points (if any) you wish to contribute to the group's success in the game;
- how many points (if any) you wish to use to resist the power of the high-power player over your contribution.

You will have two separate pots of 100 points: the "contributions" pot and the "resistance" pot. You can use these pots respectively for your contribution toward the group's success and your decision to resist the power of the high-power player in the group.

Any unused points from the two pots will be added to your total earnings from the round.

Moreover, you will be asked to specify some of your expectations about the game.

The text depended on the inter-group contest difficulty variable:

> **High difficulty**
>
> What is your group's position this round? In this round, your group is in a disadvantageous position. This means that the final contributions of the low-power players in your group will be decreased by 40%. Thus, they will have to contribute relatively more to win the prize.
>
> **Low difficulty**
>
> What is your group's position this round?
>
> In this round, your group is in an advantageous position. This means that the final contributions of the low-power players in your group will be increased by 40%. Thus, they will have to contribute relatively less to win the prize.

The text depended on the time constraint variable:

> **Time pressure**
>
> What is your time constraint this round?
>
> You will make your decisions under time pressure, i.e. you will have 10 seconds for each decision.
>
> **Time delay** What is your time constraint this round?
>
> You will make your decisions under time delay, i.e. you will have to wait 15 seconds before you can make each decision.

The remained of the text was the same for all low-power players:

> Remember, you are playing the game with real players like you.
>
> This means that you may have to wait until all players make their decisions before you can proceed to the next round.

The remainder of the text on the screenshot remained the same across all conditions for all players.

C.5.3 Decision views

Contribution Decision

In each round, low-power players had to make a contribution decision (see a sample in Figure C.5). This decision was made only by low-power players.

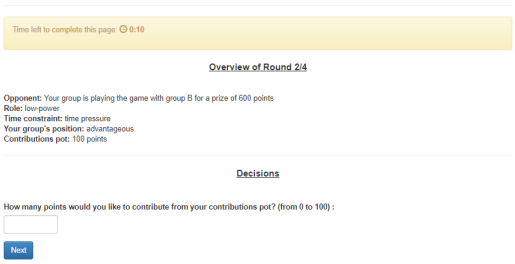


Figure C.5: Contribution decision view for Experiment 3b

The text depended on the time constraint condition:

> **Time pressure**
>
> Time constraint: time pressure
>
> **Time delay**
>
> Time constraint: time delay

The text depended on the inter-group contest difficulty condition:

> **High difficulty**
>
> Your group's position: disadvantageous
>
> **Low difficulty**
>
> Your group's position: advantageous

The remainder of the text on the screenshot remained the same across all conditions for low-power players.

Resistance decision

In each round, low-power players also had to make a contribution decision (see a sample in Figure C.6).

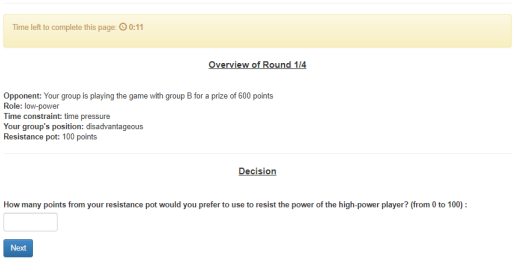


Figure C.6: Resistance decision view for Experiment 3b

This decision was made only by low-power players.

The text depended on the time constraint condition:

> **Time pressure**
>
> Time constraint: time pressure
>
> **Time deplay**
>
> Time constraint: time delay

The text depended on the inter-group contest difficulty condition:

> **High difficulty**
>
> Your group's position: disadvantageous
>
> **Low difficulty**
>
> Your group's position: advantageous

The remainder of the text on the screenshot remained the same across all conditions for low-power players

Power use decision

In each round, high-power players had to make a power-use decision (see a sample in Figure C.7). This decision was not analysed, as it was not connected to the research hypotheses. It was only used to avoid deception.

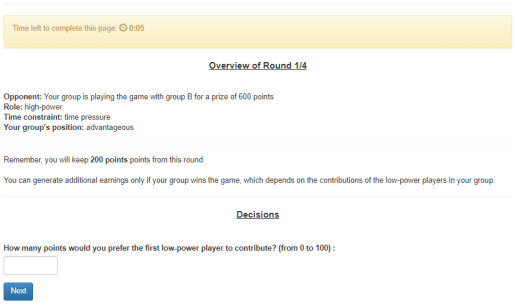


Figure C.7: Power use decision view for Experiment 3b

This decision was made only by low-power players.

The text depended on the time constraint condition:

> **Time pressure**
>
> Time constraint: time pressure
>
> **Time delay**
>
> Time constraint: time delay

The text depended on the inter-group contest difficulty condition:

> **High difficulty**
>
> Your group's position: disadvantageous
>
> **Low difficulty**
>
> Your group's position: advantageous

The remainder of the text on the screenshot remained the same across all conditions for low-power players

C.5.4 Round outcome view

At the end of each round, players saw a round outcome view (see a sample in Figure C.8).

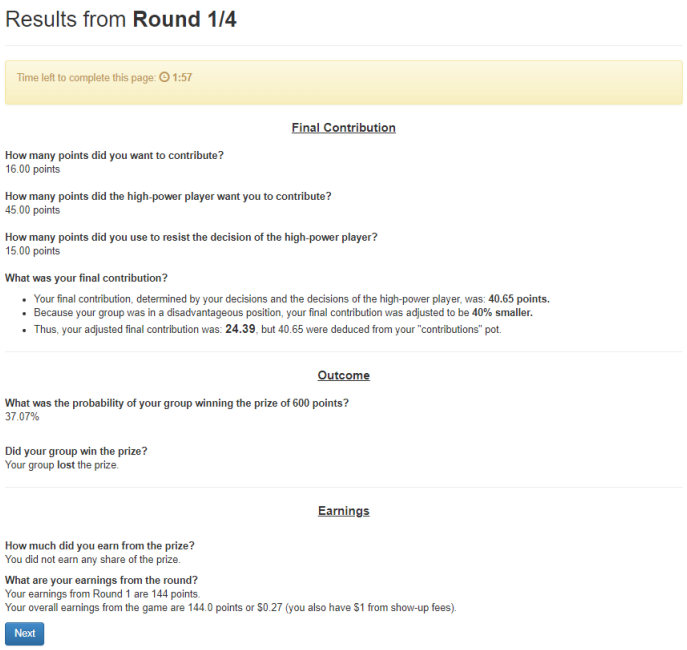


Figure C.8: Round outcome view for Experiment 3b

Some of the text depended on the player type variable:

> **Low-power players**
>
> How many points did you want to contribute?
>
> X points
>
> How many points did the high-power player want you to contribute?
>
> X points
>
> How many points did you use to resist the decision of the high-power player?
>
> X points
>
> What was your final contribution?
>
> Your final contribution, determined by your decisions and the decisions of the high-power player, was: X points.

High-power players

NO TEXT

Furthermore, for the low-power players only, some of the text depended on the inter-group contest difficulty variable:

High difficulty

Because your group was in a disadvantageous position, your final contribution was adjusted to be 40% smaller. Thus, your adjusted final contribution was: X points, but X points were deduced from your "contributions" pot.

Low difficulty

Because your group was in an advantageous position, your final contribution was adjusted to be 40% bigger. Thus, your adjusted final contribution was: x points, but only X points were deduced from your "contributions" pot.

Some of the text depended on the player type variable:

High-power

How many points did you kept from your endowment?

Because you were the high-power player, you kept X points as part of your payoff.

Low-power players

How much did you earn from the prize?

[UPON WINNING] Your individual share of the prize is X points.

[UPON LOSING] You did not earn any share of the prize.

C.6 Models for Experiment 3b

For all models in Experiment 3b I removed the correlations between the random slopes and the interaction between the random-effects variables to simplify the structure of the model. This allowed for a successful execution without convergence errors.

C.6.1 Contribution model

```
## model specification

contribution ~ constraint*diffculty*gender +

    (1 + constraint+difficulty | id)
```

Table C.5: LME model of contribution in Experiment 3b. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
constraint	3.18	1, 232.58	0.076 +	0.002
difficulty	2.88	1, 233.85	0.091 +	0.002
gender	0.00	1, 234.78	0.951	< 0.001
constraint:difficulty	0.23	1, 232.21	0.631	< 0.001
constraint:gender	0.07	1, 232.58	0.796	< 0.001
difficulty:gender	0.09	1, 233.85	0.77	< 0.001
constraint:difficulty:gender	0.03	1, 232.21	0.872	< 0.001

C.6.2 Resistance model

```
## model specification

resistance ~ constraint*difficulty*gender +

    (1 + constraint+difficulty | id)
```

Table C.6: LME model of resistance in Experiment 3b. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
constraint	3.70	1, 233.12	0.056 +	0.002
difficulty	1.22	1, 233.88	0.271	< 0.001
gender	3.97	1, 235.05	0.047 *	0.01
constraint:difficulty	1.84	1, 233.34	0.176	0.001
constraint:gender	1.02	1, 233.12	0.313	< 0.001
difficulty:gender	3.78	1, 233.88	0.053 +	0.002
constraint:difficulty:gender	11.87	1, 233.34	< 0.001 ***	0.007

Table C.7: EMM contrasts of resistance for gender by time constraint and inter-group contest difficulty in Experiment 3b. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	constraint	complexity	EMM	SE	DF	t-ratio	p	es
female vs. male	delay	high difficulty	2.70	4.39	296.03	0.61	0.539	0.12
female vs. male	pressure	high difficulty	16.73	4.39	299.84	3.81	< 0.001 ***	0.71
female vs. male	delay	low difficulty	6.98	4.22	301.46	1.65	0.099 +	0.30
female vs. male	pressure	low difficulty	-0.43	4.18	305.99	-0.10	0.919	-0.02

D

Study 4

D.1 Methods

Study 4 was composed of two online experiments. Experiment 4a was executed with a sample of UK Christian participants, recruited through the Prolific Academic platform (Palan & Schitter, 2018). Experiment 4b was executed with a sample of ethnic Bulgarian participants, recruited through a convenience sample and the Prolific Academic platform. Both experiments were executed asynchronously, thus participants were not aware of the contest outcomes and of their earnings from the game. As in Study 2, this allowed me to use the decisions of each participant as an input into a Monte Carlo simulation.

Procedure Participants in both studies went through information sheets, signed consent forms, and read the instructions. They were then told that they will be

assigned into groups of four players and were asked to play four contest games.

Hierarchy and power In both experiments, all participants were asked to reach a group decision. Each participant was asked to make a power use decision by being asked how much s/he wants each group member in the group to contribute toward the total contribution of the group.

Groups were divided into two types: egalitarian and hierarchical. In egalitarian groups the group decision was the mean of all power use decisions. Thus, in this case all group members influenced equally the group decision. In hierarchical groups participants were divided into two player types: high-power and low-power players. The power use decision of the high-power players had a greater weight over the group decision, while the power use decision of the low-power players had a lower weight over the group decision. Thus, in hierarchical groups group members influenced unequally the group decision, with members of higher power having disproportionately more influence.

Once the group decision was reached, participants were told that the group decision will influence their adjusted contribution decisions, similarly to how the high-power players were influencing the contribution decisions of low-power players in Study 3. Each participant was told that s/he will have to make a (i) contribution decision to help his/her group win the contest against its opponent and (ii) a resistant decision to resist the power of the group over his/her contribution decision, which can be seen as indicative for the resistance preference of the player.

Manipulations Across both experiments in Study 4 I manipulated whether participants were assigned to play the experiment in hierarchical or in egalitarian groups. Within hierarchical groups, half of the individuals were assigned to play as high-power players, while the other half were assigned to play as low-power players. Moreover, in both experiments I manipulated the time constraints of each

decision by asking participants to make them either under time pressure or under time delay. Finally, I manipulated the information participants received about their opponents in the contest. In Experiment 4a in half of the contests participants were told that their group of UK Christian players will play against a group of UK Muslim players, while in the other half they were told that their opponent is composed of UK Christian participants like them. In Experiment 4b ethnic Bulgarian participants were told that they will play the contest either against a group of ethnic Roma players or a group of ethnic Bulgarians.

Manipulations of conflict The selection of these two groups (ethnic Bulgarians and UK Christian participants) and their antagonistic groups (ethnic Roma and UK Muslim) was done based on the history of inter-group tension between the groups.

Ethics Study 4 was approved by the Departmental Research Ethics Committee, School of Anthropology and Museum Ethnography, University of Oxford.

Payments In Experiment 4a participants were paid a £0.85 show-up fee and a bonus of £0.35 for their participation. Thus, the earning for each participant was £1.2. In Experiment 4b all participants were not paid directly, but were given a probability to win a fixed prize of £400. More specifically, each participant received an equal probability to win the prize as all other participants (0.0033% or $\frac{1}{300}$). However, if a participant was recruited through the Prolific Academic platform s/he received a show-up fee of £0.85, due to requirements imposed by the Prolific Academic platform.

D.2 Simulation

Introduction As both experiments in Study 4 were executed asynchroniously and without feedback, I developed a simulation, based on the technique used in Study 2. The goal of the simulation was to estimate the expected net benefit and the expected adjusted contribution of each player based on her/his decisions during the game. An overview of all steps can be seen in Figure D.1.

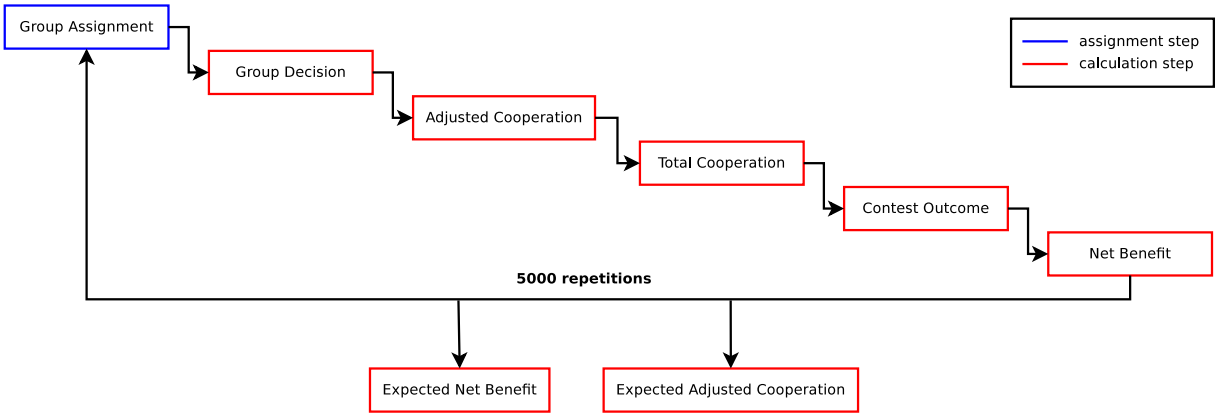


Figure D.1: Graphical representation of the Monte Carlo simulation structure for Study 4.

Development The simulation was divided into eight steps. I will aim to illustrate the important calculations in each step.

Step 1: Assignment to groups All players were assigned randomly to groups of four players. In hierarchical groups, two of the group members were high-power players, while the remaining two members were low-power players. After each iteration, participants were re-shuffled randomly into new groups.

Step 2: Calculation of group decision Within each iteration, all participants were asked how much do they wish each group member to contribute (power use decision). The answer to this question of each participant formed the basis to calculate his/her group's decision, which influences subsequently all individual

contribution decisions of all its players. The group decision depended on the system type to which the players were assigned to.

In egalitarian groups, the group decision (Π_i) was the mean of all individual power use decisions or:

$$\Pi_i = \frac{\sum_{i=1}^{N} \pi_i}{N} \tag{D.1}$$

where π_i is the power use decision of each player and N is the number of players in the group.

In hierarchical groups, the group decision was the weighted mean of all individual power use decisions, or:

$$\Pi_i = \sum_{i=1}^{N} \pi_i \times \omega_i \tag{D.2}$$

where w_i is the weight of each player's power use decision over the group decision. In hierarchical groups, high-power players received a weight of their power use decision of 40% (e.g. $\omega_i = 0.4$), while low-power players received a weight of their power use decisions of 10% (e.g. $\omega_i = 0.1$).

Step 3: Calculation of adjusted contribution Each player was told that his/her adjusted contribution decision depended on her/his contribution preference, on her/his resistance preference, and on the group decision. To formalize this dependencies, the simulation used the following function:

$$x_i^{adj} = x_i \frac{r_i}{r_{max}} + \Pi_i(1 - \frac{r_i}{r_{max}}) \tag{D.3}$$

where x_i^{adj} is the adjusted contribution, x_i is the contribution preference, r_i is the resistance preference, and r_{max} is the maximum possible resistance (e.g. 100 points) of the focal player, while Π_i is the group decision of the focal player's group. Thus,

the adjusted contribution was calculated based on the focal player's preferences for contribution and for resistance, and on the group decision.

Step 4: Calculation of total contribution For each group, the simulation calculated a total contribution, which was the sum of all individual adjusted contribution decisions, e.g. $X_i = \sum_{i=1}^{N} x_i^{adj}$.

Step 5: Assignment of groups to pairs All groups of four players were assigned into pairs with another group to play the contest for a prize. The assignment was done randomly by the simulation software.

Step 6: Calculation of contest outcome Groups in each pair played a contest game ($P_i = \frac{X_i}{X_i+X_j}$), where the probability of the focal group winning the price depends on its total contribution (X_i) relative to the total contribution of their opponent (X_j). Thus, P_i for each group was estimated by the simulation software. I executed a Bernoulli trial which determined which group has won each contest. When the groups had the same total contribution (e.g. when $X_i = X_j$) the outcome of the contest was determined randomly.

Step 7: Calculation of net benefits Once the contest outcome for each group was determined, the simulation calculated the net benefit of each decision as $b_i = l_i^c + l_i^r + w_i$, where b_i is the net benefit of player i, l_i^c is the leftover after his/her contribution decision, l_i^r is the leftover after his/her resistance decision, and w_i is the share of the prize won by player i's group. The leftover from the contribution decision for player i (l_i^c) was calculated as the maximum contribution (x_{max}) minus the adjusted contribution decision of the player (x_i^{adj}), e.g. as $x_{max} - x_i^{adj}$. The leftover from the resistance decision of player i (l_i^r) was calculated as the maximum resistance (r_{max}) minus the resistance preference of player i (r_i), e.g. as $r_{max} - r_i$. The share of the prize (w_i) was set to 200 points in this experiment, as each of the four

participants received 25% of the contest prize of 800 points. The share of the prize was added to the net benefit of player i only if her/his group has won the contest.

Step 8: Calculation of expected net benefit and expected adjusted contribution Steps 1-7 were executed 5000 times. The expected net benefit ($E[b_i]$) for each decision was calculated over all repetitions with the following function:

$$E[b_i] = \frac{\sum_{j=1}^{N} b_{ij}}{NR} \tag{D.4}$$

where b_{ij} is the net benefit for player i at repetition j, and NR is the number of repetitions. The expected adjusted contribution ($E[x_i^{adj}]$) for each decision was calculated as:

$$E[x_i^{adj}] = \frac{\sum_{j=1}^{N} x_{ij}^{adj}}{NR} \tag{D.5}$$

where x_{ij}^{adj} is the adjusted contribution of player i at repetition j, while NR is the number of repetitions.

D.3 Analytical framework

As in all previous experiments, for each dependent variable of interest I constructed a linear mixed effects (LME) model by fitting the maximal random structure justified by the design and the data complexity.

D.4 Materials for Experiment 4a

D.4.1 Instructions

Instruction 1: Earnings

> You will be paid after the end of the experiment, based on your performance.
>
> The amount you will receive depends on your decisions, so please follow ALL instructions carefully.
>
> You will be later quizzed on your understanding of the game, so it is vital to understand its rules.
>
> Your current decisions will be matched with the decisions of other participants in the experiment a couple of days after its end. Based on your and their performance, you will have the chance to earn points which will be converted to UK pounds at an exchange rate of 1 point = £0.00044.
>
> You will receive your earnings directly into your account approximately 1 week after the end of the session.
>
> You will receive your show-up fee (£0.85) after the end of today's session and on average £0.35 in bonus payments, based on the number of points you have collected.

Instruction 2: Selection

> You have been selected to participate in this experiment because your religious affiliation.
>
> Previously, you have been asked the following question:
>
> "What is your religious affiliation?"
>
> You have stated that your religious affiliation is "Christianity".You have been selected to participate in this experiment because your religious affiliation.
>
> Previously, you have been asked the following question:
>
> "What is your religious affiliation?"

> You have stated that your religious affiliation is "Christianity".

Instruction 3: Out-group

> In this experiment all participants will play a simple game in groups of 4.
>
> Participants will be divided into 2 types of groups, based on their religious affiliation: Christian and Muslim.
>
> Participants will be assigned to one of the two groups based on their answer to the aforementioned religious affiliation question.
>
> All participants in the experiment are from the United Kingdom.

Instruction 4: Attitude Questions

> Now you will be asked two questions regarding your general attitude toward the two religious groups.
>
> Please, answer the questions as honestly as possible.
>
> The study is anonymous so your answers cannot be traced back to you in any way.
>
> **What is your general attitude regarding the UK Muslim religious group?**
>
> - very negative
> - negative
> - slightly negative
> - neutral
> - slightly positive
> - positive
> - very positive
>
> **What is your general attitude regarding the UK Christian religious group?**
>
> - very negative
> - negative

- slightly negative
- neutral
- slightly positive
- positive
- very positive

Instruction 5: Anonymity

The experiment is completely anonymous.

All participants are online users and their identity will not be revealed, neither during nor after today's experiment, as it is not known by the researchers.

You will not know who the other participants are and they will not know who you are.

Instruction 6: Group Formation

The study includes 4 rounds.

At the beginning of each round you are randomly matched with 3 other participants to form a group of 4 participants.

All players in your group will be with the same religious affiliation as you (e.g. Christian).

In each round, your group will compete against one group in a game for a prize.

The other group will be made up entirely of Christian or it will be made up entirely of Muslims.

Instruction 7: The game

Remember, in each round your group will compete against another group in a game for a prize.

The prize will be 800 points.

You will play 4 rounds of the game.

> The chance of winning the prize is determined by the total contribution made by the players in your group compared to the total contribution made by the players in the other group.
> The total contribution is the sum of the contributions made by all 4 players.
> The group with higher total contribution will have a higher chance of winning the prize.
> Example: For example, if the players in your group contributed 60 points in total, while the players in the other group contributed 40 points in total, your group will have a 60% chance of winning the prize, while the other group will have a 40% chance.

Instruction 8: Earnings

> If your group wins the prize, the prize will be divided equally among all group members.
> This means that each group member will receive 200 points from the prize of 800 points.

Instruction 9: Rounds against Christian groups

> In some rounds, your group of Christian players will play the game against a group of Christian players.

Instruction 10: Rounds against Muslim groups

> In other rounds, your group of Christian players will play the game against a group of Muslim players.
> At the beginning of each round, you will find information about whether your group will play against a Christian or against a Muslim group. This information will be on your screen while you make your decisions.

Instruction 11: Rounds with time pressure

> Some rounds are time pressure rounds.
>
> In these rounds you have 10 seconds to make each of your decisions.

Instruction 12: Rounds with time delay

> Other rounds are time delay rounds.
>
> In these rounds you have to wait 15 seconds before you make each of your decisions.
> At the beginning of each round, you will find information about whether the round is a time pressure or a time delay round. This information will be on your screen while you make your decisions.

Instruction 13: Group decision

> **Hierarchical groups** In each round, your group of 4 players will be asked to reach a group decision.
> Each player will be asked to make a choice about how many points s/he wants each group member to contribute.
> The group decision will be the average of these choices, with some choices having more importance (see next Instruction).

> **Egalitarian groups** Group decision
>
> In each round, your group of 4 players will be asked to reach a group decision.
> Each player will be asked to make a choice about how many points s/he wants each group member to contribute.
> The group decision will be the average of these choices.
> This means that each player will determine 25% of the group decision.

Instruction 13: Roles

> **Hierarchical groups only** There are two roles in the game: high-power players and low-power players.

> In each group of 4 players, 2 player will have high power, while the other 2 players will have low power.
> Your role will determine the importance of your decision for your group's decision.
> The high-power players will have more influence over the group's decision. Each of the high-power players will influence 40% of the group decision.
> The low-power players will have less influence over the group's decision. Each of the low-power players will influence only 10% of the group decision.
> Thus, if you are assigned to be a high-power player, your choice will be more important than if you are assigned to be a low-power player.
> You will be randomly assigned to one role at the beginning of the game.

Instruction 14: Your pots

> You will begin each of the 4 rounds with two pots of 100 points each: the contribution pot and the resistance pot.
> You will be able to make a contribution decision and a resistance decision using your pots.

Instruction 15: Contribution decision

> You can contribute any number of points from your contribution pot to your group's total contribution.
> Remember, your group's total contribution affects your group's success in the game against the other group. The higher your group's total contribution, the higher its chances of winning the prize of 800 points.
> The group decision, which is determined by all players in the group, will influence your contribution decision (see next Instruction).
> Any unused points from the contribution pot will be added to your total earnings from the round.

Instruction 16: Resistance decision

You can use any number of points from your resistance pot to resist the group decision.

The number of points you use from your resistance pot affects how much of your final contribution is determined by you and how much is determined by the group decision.

Remember that the group's decision is influenced more by the high-power players than by the low-power players.

The more points you use towards your resistance decision, the more you will reduce the group's influence over your decision.

Example: Imagine a situation where you prefer to contribute 50 points from your contribution pot, whereas the group decision is that you should contribute 100 points:

- If you use 100 points from your resistance pot, you will control 100% of your decision. In this scenario, you will contribute your preferred amount of 50 points;
- If you use 50 points from your resistance pot, you will control 50% of your decision, and the other 50% will be controlled by the group. In this scenario, you will actually contribute 75 points;
- If you use 0 points from your resistance pot, you will control 0% of your decision. In this scenario, you will actually contribute 100 points, as decided by the group.

Any unused points from the resistance pot will be added to your total earnings from the round.

Instruction 17: A short summary

Hierarchical groups You will be assigned to a group of 4 players (including you).

All players in your group will be Christian.

All players in the group will be asked to reach a group decision.

You will be asked how many points do you want each group member to contribute.

The group decision will be the average of these choices, with some choices having more importance.

In each group, 2 players will have high power, while the other 2 players will have low power. High-power players will influence 40% of the group decision each; Low-power players will influence only 10% of the group decision each. All players will be asked to make two further decisions:

Players will be asked to contribute to the group's success with their contribution pot. Their contribution decision is determined by their preference and by the group decision; Players will be asked to resist the power of the group with their resistance pot. The more points you use from your resistance pot, the more control you will have over your final contribution. Any unused points from your contribution and resistance pots will be added to your total earnings from each round.

Your group will be playing the game with another group for a prize of 800 points. The group whose players contribute more will have a higher chance of winning the prize.

In some rounds your group of Christian participants will play against another group of Christian participants. In other rounds your group will play against a group of Muslim participants.

Finally, in some rounds you will have 10 seconds to make each of your decisions, while in others you will have to wait 15 seconds before you can make each of your decisions.

Egalitarian groups A short summary

You will be assigned to a group of 4 players (including you).

All players in your group will be Christian.

All players in the group will be asked to reach a group decision.

You will be asked how many points do you want each group member to contribute.

The group decision will be the average of these choices.

This means that each player will determine 25% of the group decision.

All players will be asked to make two further decisions:

Players will be asked to contribute to the group's success with their contribution pot. Their contribution decision is determined by their preference and by the group decision; Players will be asked to resist the power of the group with their resistance pot. The more points you use from your resistance pot, the more control you will have over your final contribution. Any unused points from your contribution and resistance pots will be added to your total earnings from each round.

Your group will be playing the game with another group for a prize of 800 points. The group whose players contribute more will have a higher chance of winning the prize.

In some rounds your group of Christian participants will play against another group of Christian participants. In other rounds your group will play against a group of Muslim participants.

Finally, in some rounds you will have 10 seconds to make each of your decisions, while in others you will have to wait 15 seconds before you can make each of your decisions.

D.4.2 Quiz

Before the beginning of the actual experiment, participants filled a short quiz.

Quiz: Introduction

Now we will ask you questions about the rules of the game.

Please, try to answer them as well as possible!

After you answer each question, you will see the correct answer.

Question 1

Question 1: What determines your chance of winning the contest?

- Your group's total contribution and the total contribution of the other group.
- Mainly your group's total contribution.
- It is randomly determined.

Answer: The correct answer is "Your group's total contribution and the total contribution of the other group."

The probability of winning the prize is determined by the total contribution of your group and by the total contribution of the other group.

For example, if your group contributed 30 points overall, while the other group contributed 70, your group will have a 30% chance of winning the prize, while the other group will have a 70% chance.

Question 2

Hierarchical groups Question 2: How much influence do high-power players have over the group decision?

- 40%
- 30%
- 10%

Answer: The correct answer is "40%".

High-power players will influence 40% of the group decision each, while low-power players will influence only 10% of the group decision each.

Egalitarian groups Question 2: How much influence do each player has over the group decision?

- 40%
- 25%
- 10%

Answer: The correct answer is "25%".

Each player will determine 25% of the group decision.

Question 3

Question 3: In a round with time pressure, how many seconds do you have to make your decision?

- 15 seconds
- 120 seconds
- 10 seconds

Answer: The correct answer is "10 seconds".

With time pressure, you have 10 seconds to make your decision.

Assignment

High-power players Now you will be assigned a role in the game.

You will be randomly assigned to be either a high-power or a low-power player.

... You have been assigned to be a HIGH-POWER PLAYER.

As a high-power player you will have more influence over the group's decision.

Each of the high-power players will influence 40% of the group decision.

You will keep your role until the end of the game (4 rounds).

Low-power player Now you will be assigned a role in the game.

You will be randomly assigned to be either a high-power or a low-power player.

... You have been assigned to be a LOW-POWER PLAYER.

> As a low-power player you will have less influence over the group's decision.
>
> Each of the low-power players will influence only 10% of the group decision.
>
> You will keep your role until the end of the game (4 rounds).

Experiment Initiation

> Now the experiment will start.
>
> You will play 4 rounds of the game.
>
> Before each round, you will see information about the round.
>
> In each round your group will be matched with another group to compete for a prize of 800 points.
>
> The other group may be either Christian or Muslim.
>
> Please, click the button and the experiment will start.

D.4.3 Round information view

Before each round, players saw a round information view (see a sample in Figure D.2).

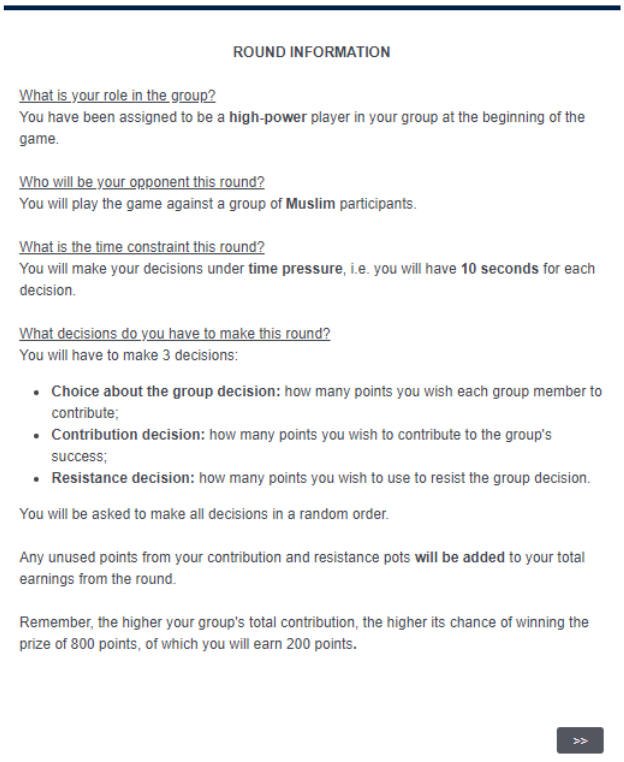


Figure D.2: Round information view for Experiment 4a

The text depended on the player type condition:

> **High-power players**
>
> What is your role in the group?
>
> You have been assigned to be a high-power player in your group at the beginning of the game.
>
> **Low-power players**
>
> What is your role in the group?
>
> You have been assigned to be a low-power player in your group at the beginning of the game.
>
> **Egalitarian players**
>
> NO TEXT

The text depended on the contest type condition:

> **In-group contests**
>
> What will be your opponent this round?
>
> You will play the game against a group of Christian participants.
>
> **Out-group contests**
>
> Who will be your opponent this round?
>
> You will play the game against a group of Muslim participants.

The text depended on the time constraint condition:

> **Time pressure** What is the time constraint this round?
>
> You will make your decisions under time pressure, i.e. you will have 10 seconds for each decision.
>
> **Time delay**
>
> What is the time constraint this round?
>
> You will make your decisions under time delay, i.e. you will have to wait 15 seconds before you can make each decision.

The remainder of the text on the screenshot remained the same across all conditions.

D.4.4 Decision view

Contribution Decision

In each round, players had to make a contribution decision (see a sample in Figure D.3).

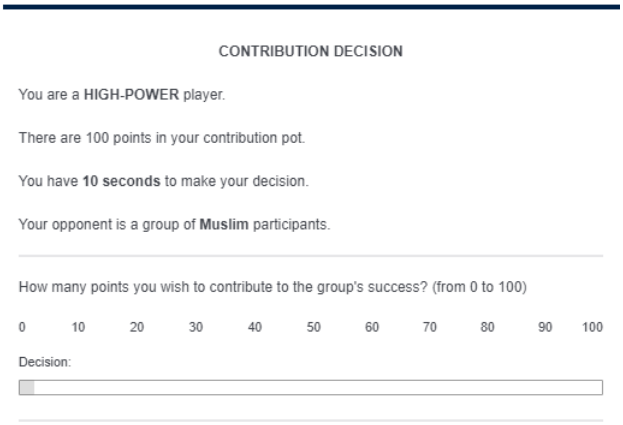


Figure D.3: Contribution decision view for Experiment 4a

The text depended on the player type condition:

> **High-power player**
>
> You are a HIGH-POWER player.
>
> **Low-power player**
>
> You are a LOW-POWER player.
>
> **Egalitarian players**
>
> RANK IS NOT MENTIONED

The text depended on the time constraint condition:

> **Time pressure**
>
> You have 10 seconds to make your decision.
>
> **Time delay**
>
> You have to wait 15 seconds before you can make your decision.

The text depended on the contest type condition:

In-group

Your opponent is a group of Christian participants.

Out-group

Your opponent is a group of Muslim participants.

The remainder of the text on the screenshot remained the same across all conditions.

Resistance decision

In each round, players also had to make a resistance decision (see a sample in Figure D.4).

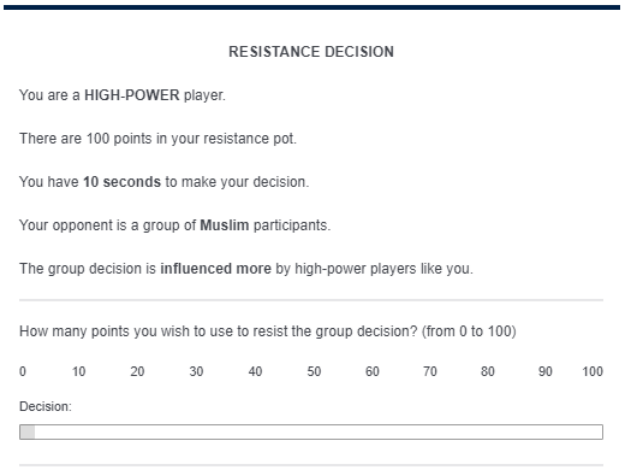


Figure D.4: Resistance decision view for Experiment 4a

The text depended on the player type condition:

High-power player

You are a HIGH-POWER player.

Low-power player

You are a LOW-POWER player.

Egalitarian players

RANK IS NOT MENTIONED

The text depended on the time constraint condition:

> **Time pressure**
>
> You have 10 seconds to make your decision.
>
> **Time delay**
>
> You have to wait 15 seconds before you can make your decision.

The text depended on the contest type condition:

> **In-group**
>
> Your opponent is a group of Christian participants.
>
> **Out-group**
>
> Your opponent is a group of Muslim participants.

The text depended on the player type condition:

> **High-power player**
>
> The group decision is influenced more by high-power players like you.
>
> **Low-power player**
>
> The group decision is influenced less by low-power players like you.
>
> **Egalitarian player**
>
> The group decision is influenced equally by all players.

The remainder of the text on the screenshot remained the same across all conditions.

Group Decision

Finally, in each round, players also had to make a group decision (see a sample in Figure D.5).

The text depended on the time constraint condition:

> **Time pressure**
>
> You have 10 seconds to make your decision.
>
> **Time delay**
>
> You have to wait 15 seconds before you can make your decision.

The text depended on the contest type condition:

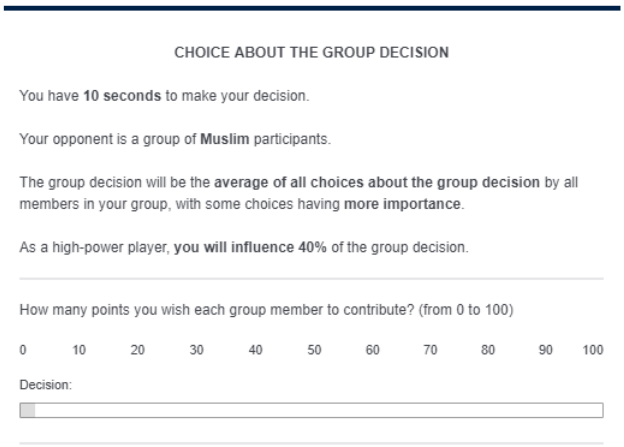


Figure D.5: Group decision view for Experiment 4a

> **In-group**
>
> Your opponent is a group of Christian participants.
>
> **Out-group**
>
> Your opponent is a group of Muslim participants.

The text depended on the system type condition:

> **Hierarchical groups**
>
> The group decision will be the average of all choices about the group decision by all members in your group, with some choices having less importance.
>
> **Egalitarian groups**
>
> The group decision will be the average of all choices about the group decision by all members in your group.

The text depended on the player type condition:

> **High-power player**
>
> As a high-power player, you will influence 40% of the group decision.
>
> **Low-power player**
>
> As a low-power player, you will influence only 10% of the group decision.
>
> **Egalitarian player**
>
> As all other players in the group, you will influence 25% of the group decision.

The remainder of the text on the screenshot remained the same across all conditions.

D.5 Models for Experiment 4a

For all models in Experiment 4a I removed the correlations between the random slopes and the interaction between the random-effects variables to simplify the structure of the model. This allowed for a successful execution without convergence errors.

D.5.1 Contribution model

```
## model specification

contribution ~ player_type*contest_type*constraint*gender*outgroup_attitude +

    (1 + contest_type+constraint | id)
```

Table D.1: LME model of contribution in Experiment 4a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
player type	0.63	2, 372.82	0.532	0.002
contest type	1.40	1, 386.69	0.238	< 0.001
constraint	6.17	1, 386.5	0.013 *	0.001
gender	2.63	1, 373.24	0.106	0.005
outgroup attitude	0.02	1, 373.24	0.901	< 0.001
player type:contest type	1.50	2, 383.87	0.225	< 0.001
player type:constraint	0.06	2, 383.71	0.944	< 0.001
contest type:constraint	1.37	1, 386.98	0.242	< 0.001
player type:gender	0.03	2, 372.82	0.967	< 0.001
contest type:gender	3.10	1, 386.69	0.079 +	< 0.001
constraint:gender	3.94	1, 386.5	0.048 *	< 0.001
player type:outgroup attitude	0.53	2, 372.82	0.588	0.002
contest type:outgroup attitude	1.82	1, 386.69	0.178	< 0.001
constraint:outgroup attitude	2.86	1, 386.5	0.092 +	< 0.001
gender:outgroup attitude	0.35	1, 373.24	0.557	< 0.001
player type:contest type:constraint	2.90	2, 384.03	0.056 +	0.001
player type:contest type:gender	1.41	2, 383.87	0.244	< 0.001
player type:constraint:gender	2.36	2, 383.71	0.096 +	0.001
contest type:constraint:gender	1.50	1, 386.98	0.222	< 0.001
player type:contest type:outgroup attitude	1.47	2, 383.87	0.23	< 0.001
player type:constraint:outgroup attitude	0.62	2, 383.71	0.541	< 0.001
contest type:constraint:outgroup attitude	1.64	1, 386.98	0.201	< 0.001
player type:gender:outgroup attitude	0.12	2, 372.82	0.889	< 0.001
contest type:gender:outgroup attitude	3.79	1, 386.69	0.052 +	< 0.001
constraint:gender:outgroup attitude	1.70	1, 386.5	0.193	< 0.001
player type:contest type:constraint:gender	3.30	2, 384.03	0.038 *	0.001
player type:contest type:constraint:outgroup attitude	0.21	2, 384.03	0.815	< 0.001
player type:contest type:gender:outgroup attitude	0.88	2, 383.87	0.414	< 0.001
player type:constraint:gender:outgroup attitude	0.21	2, 383.71	0.809	< 0.001
contest type:constraint:gender:outgroup attitude	0.10	1, 386.98	0.748	< 0.001
player type:contest type:constraint:gender:outgroup attitude	1.22	2, 384.03	0.297	< 0.001

Table D.2: EMM contrasts of contribution for player type by contest type in Experiment 4a. Significance levels are represented as + for $p < 0.1$, * for $p < 0.05$, ** for $p < 0.01$, and *** for $p < 0.001$.

contrast	contest type	EMM	SE	DF	t-ratio	p	es
egalitarian vs. high-power	in-group	-4.05	4.01	370.50	-1.01	0.572	-0.27
egalitarian vs. low-power	in-group	3.16	3.67	370.04	0.86	0.665	0.21
high-power vs. low-power	in-group	7.21	4.52	369.96	1.59	0.25	0.48
egalitarian vs. high-power	out-group	-2.45	4.07	384.49	-0.60	0.819	-0.16
egalitarian vs. low-power	out-group	-0.13	3.68	370.92	-0.04	0.999	-0.01
high-power vs. low-power	out-group	2.32	4.58	382.15	0.51	0.868	0.15

D.5.2 Expected net benefit model

```
## model specification

expected_net_benefit ~ player_type*contest_type*constraint*gender*outgroup_attitude +

    (1 + contest_type+constraint | id)
```

Table D.3: LME model of expected net benefit in Experiment 4a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
player type	3.49	2, 370	0.032 *	0.013
contest type	3.50	1, 370	0.062 +	< 0.001
constraint	2.07	1, 370	0.151	< 0.001
gender	2.49	1, 370	0.116	0.005
outgroup attitude	0.91	1, 370	0.34	0.002
player type:contest type	2.77	2, 370	0.064 +	0.001
player type:constraint	2.09	2, 370	0.126	0.001
contest type:constraint	0.05	1, 370	0.826	< 0.001
player type:gender	1.55	2, 370	0.213	0.006
contest type:gender	2.77	1, 370	0.097 +	< 0.001
constraint:gender	4.92	1, 370	0.027 *	0.001
player type:outgroup attitude	0.69	2, 370	0.504	0.003
contest type:outgroup attitude	8.75	1, 370	0.003 **	0.002
constraint:outgroup attitude	4.37	1, 370	0.037 *	0.001
gender:outgroup attitude	0.72	1, 370	0.396	0.001
player type:contest type:constraint	1.31	2, 370	0.27	< 0.001
player type:contest type:gender	2.16	2, 370	0.117	0.001
player type:constraint:gender	0.08	2, 370	0.924	< 0.001
contest type:constraint:gender	1.07	1, 370	0.302	< 0.001
player type:contest type:outgroup attitude	0.91	2, 370	0.402	< 0.001
player type:constraint:outgroup attitude	0.51	2, 370	0.601	< 0.001
contest type:constraint:outgroup attitude	0.14	1, 370	0.709	< 0.001
player type:gender:outgroup attitude	0.77	2, 370	0.463	0.003
contest type:gender:outgroup attitude	11.65	1, 370	< 0.001 ***	0.003
constraint:gender:outgroup attitude	0.88	1, 370	0.348	< 0.001
player type:contest type:constraint:gender	0.81	2, 370	0.447	< 0.001
player type:contest type:constraint:outgroup attitude	0.86	2, 370	0.422	< 0.001
player type:contest type:gender:outgroup attitude	1.93	2, 370	0.147	< 0.001
player type:constraint:gender:outgroup attitude	0.53	2, 370	0.59	< 0.001
contest type:constraint:gender:outgroup attitude	0.27	1, 370	0.601	< 0.001
player type:contest type:constraint:gender:outgroup attitude	0.09	2, 370	0.914	< 0.001

Table D.4: EMM contrasts of expected net benefit for player type in Experiment 4a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	EMM	SE	DF	t-ratio	p	es
egalitarian vs. high-power	12.98	4.93	370.00	2.63	0.024 *	0.68
egalitarian vs. low-power	2.65	4.51	370.00	0.59	0.827	0.14
high-power vs. low-power	-10.33	5.57	370.00	-1.86	0.153	-0.54

Table D.5: EMM contrasts of expected net benefit for player type by contest type in Experiment 4a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	contest type	EMM	SE	DF	t-ratio	p	es
egalitarian vs. high-power	in-group	14.50	5.18	370.00	2.80	0.015 *	0.76
egalitarian vs. low-power	in-group	-0.37	4.74	370.00	-0.08	0.997	-0.02
high-power vs. low-power	in-group	-14.87	5.85	370.00	-2.54	0.031 *	-0.78
egalitarian vs. high-power	out-group	11.46	5.32	370.00	2.15	0.081 +	0.60
egalitarian vs. low-power	out-group	5.66	4.87	370.00	1.16	0.476	0.30
high-power vs. low-power	out-group	-5.79	6.00	370.00	-0.97	0.599	-0.30

D.5.3 Expected adjusted contribution model

```
## model specification

expected_contribution_adj ~ system_type*contest_type*constraint*gender*outgroup_attitude +

    (1 + contest_type+constraint | id)
```

Table D.6: LME model of expected adjusted contribution in Experiment 4a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
system type	2.49	1, 374	0.115	0.005
contest type	1.15	1, 374	0.284	< 0.001
constraint	7.61	1, 374	0.006 **	0.002
gender	0.66	1, 374	0.418	0.001
outgroup attitude	0.01	1, 374	0.906	< 0.001
system type:contest type	1.92	1, 374	0.167	< 0.001
system type:constraint	2.35	1, 374	0.127	< 0.001
contest type:constraint	0.22	1, 374	0.643	< 0.001
system type:gender	0.84	1, 374	0.36	0.002
contest type:gender	4.04	1, 374	0.045 *	0.001
constraint:gender	1.50	1, 374	0.221	< 0.001
system type:outgroup attitude	0.78	1, 374	0.377	0.001
contest type:outgroup attitude	5.81	1, 374	0.016 *	0.002
constraint:outgroup attitude	3.52	1, 374	0.061 +	< 0.001
gender:outgroup attitude	0.05	1, 374	0.818	< 0.001
system type:contest type:constraint	6.99	1, 374	0.009 **	0.002
system type:contest type:gender	1.72	1, 374	0.191	< 0.001
system type:constraint:gender	1.17	1, 374	0.279	< 0.001
contest type:constraint:gender	0.47	1, 374	0.496	< 0.001
system type:contest type:outgroup attitude	0.19	1, 374	0.667	< 0.001
system type:constraint:outgroup attitude	0.57	1, 374	0.453	< 0.001
contest type:constraint:outgroup attitude	0.62	1, 374	0.431	< 0.001
system type:gender:outgroup attitude	1.25	1, 374	0.264	0.002
contest type:gender:outgroup attitude	10.43	1, 374	0.001 **	0.003
constraint:gender:outgroup attitude	0.22	1, 374	0.636	< 0.001
system type:contest type:constraint:gender	2.83	1, 374	0.093 +	< 0.001
system type:contest type:constraint:outgroup attitude	0.01	1, 374	0.942	< 0.001
system type:contest type:gender:outgroup attitude	0.10	1, 374	0.753	< 0.001
system type:constraint:gender:outgroup attitude	0.12	1, 374	0.733	< 0.001
contest type:constraint:gender:outgroup attitude	0.59	1, 374	0.444	< 0.001
system type:contest type:constraint:gender:outgroup attitude	1.34	1, 374	0.248	< 0.001

Table D.7: EMM contrasts of adjusted contribution for system type by contest type and time constraint in Experiment 4a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	contest type	constraint	EMM	SE	DF	t-ratio	p	es
egalitarian vs. hierarchical	in-group	delay	-4.30	2.01	444.06	-2.14	0.033 *	-0.46
egalitarian vs. hierarchical	out-group	delay	-2.95	1.96	447.47	-1.50	0.134	-0.32
egalitarian vs. hierarchical	in-group	pressure	0.76	1.97	446.79	0.38	0.701	0.08
egalitarian vs. hierarchical	out-group	pressure	-4.13	2.04	441.73	-2.03	0.043 *	-0.44

D.5.4 Resistance model

```
## model specification

resistance ~ player_type*contest_type*constraint*gender*outgroup_attitude +

    (1 + contest_type+constraint | id)
```

Table D.8: LME model of resistance in Experiment 4a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
player type	3.20	2, 371.82	0.042 *	0.012
contest type	3.04	1, 382.23	0.082 +	< 0.001
constraint	0.24	1, 379.58	0.625	< 0.001
gender	2.28	1, 372.06	0.132	0.004
outgroup attitude	1.28	1, 372.06	0.258	0.002
player type:contest type	2.20	2, 380.52	0.112	0.001
player type:constraint	2.00	2, 378.16	0.137	0.001
contest type:constraint	0.07	1, 382.37	0.791	< 0.001
player type:gender	1.58	2, 371.82	0.208	0.006
contest type:gender	3.12	1, 382.23	0.078 +	< 0.001
constraint:gender	3.86	1, 379.58	0.05	0.001
player type:outgroup attitude	0.80	2, 371.82	0.451	0.003
contest type:outgroup attitude	7.67	1, 382.23	0.006 **	0.002
constraint:outgroup attitude	2.53	1, 379.58	0.112	< 0.001
gender:outgroup attitude	0.77	1, 372.06	0.382	0.001
player type:contest type:constraint	1.03	2, 380.43	0.359	< 0.001
player type:contest type:gender	1.58	2, 380.52	0.208	< 0.001
player type:constraint:gender	0.19	2, 378.16	0.826	< 0.001
contest type:constraint:gender	2.00	1, 382.37	0.158	< 0.001
player type:contest type:outgroup attitude	0.46	2, 380.52	0.632	< 0.001
player type:constraint:outgroup attitude	1.33	2, 378.16	0.266	< 0.001
contest type:constraint:outgroup attitude	1.47	1, 382.37	0.226	< 0.001
player type:gender:outgroup attitude	0.59	2, 371.82	0.555	0.002
contest type:gender:outgroup attitude	11.84	1, 382.23	< 0.001 ***	0.003
constraint:gender:outgroup attitude	0.47	1, 379.58	0.491	< 0.001
player type:contest type:constraint:gender	1.33	2, 380.43	0.265	< 0.001
player type:contest type:constraint:outgroup attitude	1.67	2, 380.43	0.19	< 0.001
player type:contest type:gender:outgroup attitude	1.31	2, 380.52	0.27	< 0.001
player type:constraint:gender:outgroup attitude	0.59	2, 378.16	0.556	< 0.001
contest type:constraint:gender:outgroup attitude	0.51	1, 382.37	0.477	< 0.001
player type:contest type:constraint:gender:outgroup attitude	0.15	2, 380.43	0.864	< 0.001

Table D.9: EMM contrasts of resistance for player type in Experiment 4a. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	EMM	SE	DF	t-ratio	p	es
egalitarian vs. high-power	-9.77	3.98	372.60	-2.45	0.039 *	-0.61
egalitarian vs. low-power	-0.56	3.64	370.68	-0.15	0.987	-0.04
high-power vs. low-power	9.21	4.49	372.54	2.05	0.102	0.58

Table D.10: EMM contrasts of resistance for contest type by gender and out-group attitude in Experiment 4a. Significance levels are represented as + for $p < 0.1$, * for $p < 0.05$, ** for $p < 0.01$, and *** for $p < 0.001$.

contrast	gender	outgroup attitude	EMM	SE	DF	t-ratio	p	es
in-group vs. out-group	female	negative	0.87	2.27	370.52	0.38	0.702	0.05
in-group vs. out-group	male	negative	-12.12	3.46	405.93	-3.50	< 0.001 ***	-0.76
in-group vs. out-group	female	positive/neutral	-0.81	1.29	365.68	-0.63	0.532	-0.05
in-group vs. out-group	male	positive/neutral	3.36	2.47	353.53	1.36	0.174	0.21

D.6 Materials for Study 4b

D.6.1 Instructions

Instruction 1: Earnings

> Настоящето изследване за вземане на решения ще бъде проведено под формата на игра.
>
> Преди същинското ѝ започване, ще прочетете инструкция за начина, по който ще се проведе, последвана от въпроси, свързани със самата игра.
>
> По време на изследването ще печелите точки, базирани на решенията, които взимате, като те ще бъдат обменяни срещу вероятност да спечелите награда от 880 лв.
>
> Наградата ще се даде под формата на томбола, като шансът да я спечелите зависи от точките, събрани по време на играта.
>
> Не забравяйте, че броят събрани точки зависи изцяло от Вашите решения по време на играта, затова, моля, прочетете ВСИЧКИ ИНСТРУКЦИИ внимателно.
>
> По време на изследването всички Ваши решения ще се сравняват с тези, дадени от други участници. Печелившият играч ще бъде обявен до 2 седмици след приключване на изследването.

Instruction 2: Selection

> Настоящето изследване се провежда под формата на игра.
>
> Всеки участник ще бъде разпределен в група от 4 играчи.
>
> Някои групи ще бъдат съставени само от етнически българи, а други – само от етнически роми.
>
> Вие ще бъдете в група от играчи с българска етническа принадлежност.

Instruction 4: Attitude Questions

Сега ще Ви зададем два въпроса за Вашата нагласа спрямо двете етнически групи участващи в изследването: роми и българи.

Моля, отговорете искрено на въпросите.

Участието в изследването е анонимно, което означава, че Вашите отговори няма да бъдат свързани с Вашата идентичност.

Каква е Вашата нагласа към ромската етническа група?

- много негативна
- негативна
- по-скоро негативна
- неутрална
- по-скоро позитивна
- позитивна
- много позитивна

Каква е Вашата нагласа към българската етническа група?

- много негативна
- негативна
- по-скоро негативна
- неутрална
- по-скоро позитивна
- позитивна
- много позитивна

Instruction 5: Anonimity

Изследвавнето е напълно анонимно.

> Идентичността на участниците няма да бъде известна нито по време, нито след днешното изследване.
>
> Вие няма да знаете идентичността на останалите участници, а те няма да знаят Вашата идентичност.

Instruction 6: Group formation

> В началото на изследването Вие и 3 други играчи ще сформирате група от 4 играчи.
>
> Всички играчи от Вашата група ще са с българска етническа принадлежност.
>
> Във всеки рунд, Вашата група ще се състезава срещу друга група в игра с награда.
>
> Участниците в другата група ще бъдат или с българска етническа принадлежност, или с ромска етническа принадлежност.

Instruction 7: The game

> Цялото изследване се състои от 4 рунда.
>
> Както бе описано по-рано, във всеки рунд Вашата група ще се състезава с друга група в игра за награда.
>
> Наградата ще бъде 800 точки.
>
> На всеки играч ще му бъде предоставена възможност да допринесе за успеха на групата си.
>
> Вероятността Вашата група да спечели наградата е базирана на приноса на всички играчи от групата сравнен с приноса на всички играчи от другата група.
>
> Групата с по-голям общ принос има по-голям шанс да спечели наградата.
>
> Пример: Ако играчите във Вашата група решат да допринесат общо 60 точки за нейния успех, а играчите от другата група решат да допринесат 40 точки, Вашата група ще има 60% шанс да спечели наградата, а другата група - 40% шанс да спечели наградата.

Instruction 8: Earnings

> Ако Вашата група сечели наградата, тя ще бъде разпределена поравно между всички играчи в нея.
>
> Това означава, че всеки член на групата ще спечели 200 точки от общите 800 точки.

Instruction 9: Rounds against Bulgarians

> В някои рундове Вашата група от българи ще играе играта срещу друга група от българи.

Instruction 10: Rounds against Roma

> В други рундове Вашата група от българи ще играе срещу група от роми.
>
> В началото на всеки рунд ще получите информация за етническата принадлежност на членовете на групата, срещу която играете. Тази информация ще е на Вашия екран докато вземате всички Ваши решения.

Instruction 11: Rounds with time pressure

> В някои рундове ще имате времево ограничение.
>
> В тези рундове ще имате по 10 секунди да вземете всяко от Вашите решения.

Instruction 12: Rounds with time delay

> В други рундове ще имате времево забавяне.
>
> В тези рундове ще трябва да изчакате 15 секунди преди да вземете всяко от Вашите решения.
>
> В началото на всеки рунд ще получите информация дали рундът е с времево ограничение или с времево забавяне. Тази информация ще е на Вашия екран докато вземате всички ваши решения.

Instruction 13: Group decision

> **Hierarchical groups** Във всеки рунд Вашата група ще трябва да достигне до общо групово решение.

Всеки от четиримата играчи ще трябва да реши колко иска да бъде приносът на всеки играч в групата.

Общото групово решение ще бъде средната между тези индивидуални решения, като индивидуалните решения на някои играчи ще имат по-голяма тежест (вижте следващата страница).

Egalitarian groups Във всеки рунд Вашата група ще трябва да достигне до общо групово решение.

Всеки от четиримата играчи ще трябва да реши колко иска да бъде приносът на всеки играч в групата.

Общото групово решение ще бъде средната между тези индивидуални решения.

Това означава, че всеки играч ще определи по 25% от груповото решение.

Instruction 13: Roles

Hierarchical groups only Във всяка група от 4 играчи, двама ще бъдат с играчи с много власт, а останалите двама ще бъдат играчи с малко власт. Ролята на играча определя тежестта на неговото индивидуално решение върху общото групово решение.

Играчите с много власт ще имат по-голяма тежест върху общото групово решение. Всеки играч с много власт ще определи 40% от груповото решение.

Играчите с малко власт ще имат по-малка тежест върху общото групово решение. Всеки играч с малко власт ще определи само 10% от груповото решение.

Ако бъдете избрани за играч с много власт, Вашият индивидуален избор ще бъде по-важен отколкото ако бъдете избран за играч с малко власт.

В началото на играта случайно ще бъдете избран за играч с много власт или за играч с малко власт във Вашата група.

Instruction 14: Your pots

В началото на всеки от четирите рунда, Вие ще получите два фонда от 100 точки: фонд за принос и фонд за съпротива.

По време на всеки рунд ще бъдете помолени да използвате тези фондове, за да определите Вашия принос и Вашата съпротива.

Instruction 15: Contribution decision

Вие можете да допринесете към успеха на Вашата група в играта като използвате точките от Вашия фонд за принос.

Спомнете си, че общият принос на всички членове на вашата група увеличава шанса ѝ за успех в играта срещу противниковата група. Групата с по-голям общ принос има по-голям шанс да спечели наградата от 800 точки.

Общото групово решение, което се определя от всички играчи в групата, ще повлияе на Вашето решение за принос (вижте следващата страница).

Всички точки, които не сте използвали, за да допринесете към успеха на Вашата група, ще бъдат добавени към Вашата печалба от рунда.

Instruction 16: Resistance decision

Вие можете да изпозвате Вашия фонд за съпротива за да се противпоставите на общото групово решение на Вашата група.

Общото групово решение ще повлияе на Вашето решение за принос.

Спомнете си, че играчите с много власт имат по-голямо влияние върху общото групово решение отколкото играчите с малко власт.

Колкото повече точки използвате от Вашия фонд за съпротива, толкова по-малко ще бъде влиянието на груповото решение върху Вашето крайно решение.

С други думи, Вашата съпротива ще определи колко от крайното Ви решение ще зависи от Вас и колко от общото групово решение.

Пример:

Представете си ситуация, в която сте предпочели да допринесете с 50 точки

от Вашия фонд за принос за успеха на групата. Също така си представете, че в тази ситуация общото групово решение е, че всеки член на групата трябва да допринесе със 100 точки за успеха на групата:

- Ако използвате 100 точки от Вашия фонд за съпротива, ще контролирате 100% от Вашето решение за принос. В този случай ще допринесете 50 точки за успеха на групата, точно както сте предпочели;
- Ако използвате 50 точки от Вашия фонд за съпротива, ще контролирате 50% от Вашето решение, а останалите 50% ще са контролирани от общото групово решение. В този случай ще допринесете 75 точки за успеха на групата;
- Ако използвате 0 точки от Вашия фонд за съпротива, ще контролирате 0% от Вашето решение. В този случай ще допринесете 100 точки за успеха на групата, точно колкото е общото групово решение.

Всички точки, които не сте използвали за да се противопоставите на общото групово решение, ще бъдат добавени към Вашата печалба от рунда.

Instruction 17: A short summary

Hierarchical groups Кратко обобщение

Вие ще бъдете включени в група от 4 играча.

Всички играчи от Вашата група ще бъдат с българска етническа принадлежност.

Във всеки рунд, Вашата група трябва да достигне до общо групово решение.

Всеки играч ще трябва да реши колко иска да бъде приносът на всеки играч в групата.

Общото групово решение ще бъде средната между тези индивидуални решения, като индивидуалните решения на някои играчи ще имат по-голяма тежест.

Във всяка група, двама играчи ще бъдат избрани да бъдат играчи с много

власт, а останалите двама играчи ще бъдата избрани да бъдат с малко власт. Всеки от играчите с много власт ще определи по 40% от общото групово решение; Всеки от играчите с малко власт ще определи по 10% от общото групово решение. Всички играчи ще бъдат помолени да вземат още две решения.

Играчите ще бъдат помолени да решат колко точки да допринесат за успеха на групата в играта срещу противниковата група чрез използването на техния фонд за принос. Решението за принос ще се определи от предпочитанията на всеки играч и от общото групово решение; Играчите ще бъдат помолени да решат дали да се противопоставят на общото групово решение чрез използването на техния фонд за съпротива. Използването на повече точки от фонда за съпротива означава, че груповото решение ще има по-малко влияние върху крайния принос на играча. Всички неизползвани точки от фондовете за принос и съпротива ще бъдат добавени към Вашата печалба от рунда.

Във всеки рунд Вашата група ще играе играта срещу друга група за награда от 800 точки. Групата с по-голям общ принос ще има по-голям шанс да спечели наградата.

В някои рундове Вашата група от етнически българи ще играе срещу друга група от етнически българи, а в други рудове - срещу група от етнически роми.

Също така, в някои рундове ще имате 10 секунди да вземете всяко от Вашите решения, а в други рундове ще трябва да изчакате 15 секунди преди да вземете всяко от Вашите решения.

Egalitarian groups Кратко обобщение

Вие ще бъдете включени в група от 4 играча.

Всички играчи от Вашата група ще бъдат с българска етническа принадлежност.

Във всеки рунд, Вашата група трябва да достигне до общо групово решение. Всеки играч ще трябва да реши колко иска да бъде приносът на всеки играч в групата.

Общото групово решение ще бъде средната между тези индивидуални решения.

Това означава, че всеки играч ще определи по 25% от груповото решение. Всички играчи ще бъдат помолени да вземат още две решения. Играчите ще бъдат помолени да решат колко точки да допринесат за успеха на групата в играта срещу противниковата група чрез използването на техния фонд за принос. Решението за принос ще се определи от предпочитанията на всеки играч и от общото групово решение; Играчите ще бъдат помолени да решат дали да се противопоставят на общото групово решение чрез използването на техния фонд за съпротива. Използването на повече точки от фонда за съпротива означава, че груповото решение ще има по-малко влияние върху крайния принос на играча. Всички неизползвани точки от фондовете за принос и съпротива ще бъдат добавени към Вашата печалба от рунда.

Във всеки рунд Вашата група ще играе играта срещу друга група за награда от 800 точки. Групата с по-голям общ принос ще има по-голям шанс да спечели наградата.

В някои рундове Вашата група от етнически българи ще играе срещу друга група от етнически българи, а в други рудове - срещу група от етнически роми.

Също така, в някои рундове ще имате 10 секунди да вземете всяко от Вашите решения, а в други рундове ще трябва да изчакате 15 секунди преди да вземете всяко от Вашите решения.

D.6.2 Quiz

Quiz Introduction

> Сега ще Ви зададем няколко въпроса за правилата на играта.

Question 1

> Въпрос 1: Какво определя шанса на Вашата група да спечели играта срещу противниковата група?
>
> - Общият принос на членовете на Вашата група и общият принос на членовете на другата група.
> - Само общият принос на членовете на Вашата група.
> - Определен е случайно.

> Answer: Правилният отговор е "Общият принос на членовете на Вашата група и общият принос на членовете на другата група."
> Вероятността Вашата група да спечели наградата се определя от общия принос на членовете на Вашата група сравнен с общия принос на членовете на противниковата група.
> Примерно, ако общият принос на Вашата група е 30 точки, а общият принос на противниковата група е 70 точки, вашата група ще има 30% шанс да спечели наградата, а противниковата група ще има 70% шанс.

Question 2

> **Hierarchical groups** Въпрос 2: Колко процента от общото групово решение ще бъде определено от всеки от играчите с много власт?
>
> - 40%
> - 30%
> - 10%

> Answer: Правилният отговор е "40%".
>
> Всеки от играчите с много власт ще определи по 40% от общото групово решение, а всеки от играчите с малко власт ще определи само по 10% от общото групово решение.

> **Egalitarian groups** Въпрос 2: Колко процента от общото групово решение ще бъде определено от всеки от играчите?
>
> - 40
> - 25
> - 10

> Answer: Правилният отговор е "25%".
>
> Всеки играч ще определи по 25

Question 3

> Въпрос 3: Колко време имате да вземете Вашите решения в рундовете с времево ограничение?
>
> - 15 секунди
> - 120 секунди
> - 10 секунди

> Answer: Правилният отговор е "10 секунди".
>
> С времево ограничение имате 10 секунди да вземете всяко от Вашите решения.

Assignment

> **High-power players** Сега ще определим Вашата роля по време на играта.
>
> На случаен принцип ще Ви бъде възложено да бъдете или играч с много власт, или играч с малко власт по време на цялото изследване.
>
> ... Беше ви възложено да бъдете ИГРАЧ С МНОГО ВЛАСТ.

> Като играч с много власт можете да определите 40% от общото групово решение във всеки рунд.
>
> Вашата роля ще бъде една и съща до края на изследването.

> **Low-power player** Сега ще определим Вашата роля по време на играта.
>
> На случаен принцип ще Ви бъде възложено да бъдете или играч с много власт, или играч с малко власт по време на цялото изследване.
>
> ... Беше ви възложено да бъдете ИГРАЧ С МАЛКО ВЛАСТ.
>
> Като играч с малко власт можете да определите само 10% от общото групово решение във всеки рунд.
>
> Вашата роля ще бъде една и съща до края на изследването.

Experiment Initiation

> Сега ще започнем изследването
>
> Ще играете 4 рунда от играта за награда от 800 точки или срещу група от етнични българи, или срещу група от етнични роми.
>
> Преди всеки рунд ще видите допълнителна информация за него.
>
> Натиснете бутона за да започнете изследването.

D.6.3 Round information view

Before each round, players saw a round information view (see a sample in Figure D.6).

The text depended on the player type condition:

> **High-power player**
>
> Каква е Вашата роля в групата?
>
> В началото на играта Ви беше възложено да бъдете играч с много власт.
>
> **Low-power player**
>
> Каква е Вашата роля в групата?
>
> В началото на играта Ви беше възложено да бъдете играч с малко власт.
>
> **Egalitarian player**

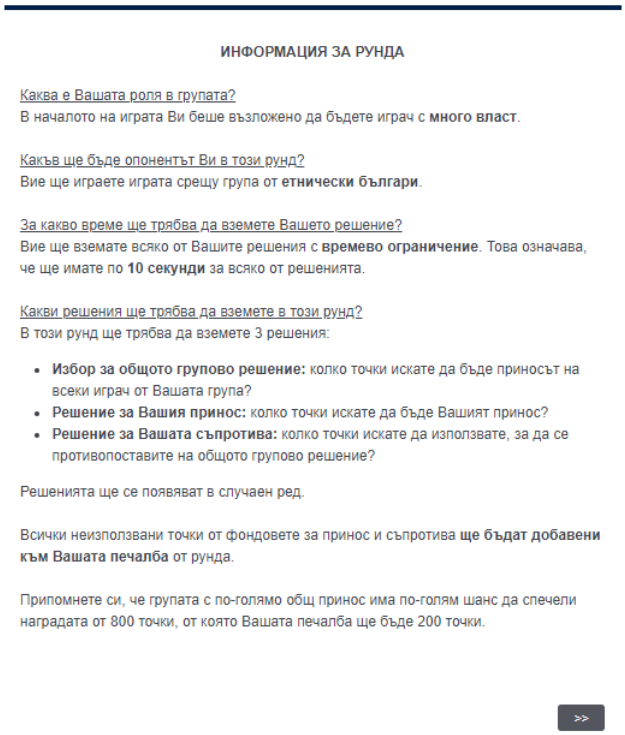


Figure D.6: Round information view for Experiment 4b

> NO TEXT

The text depended on the time constraint condition:

> **Time constraint**
>
> За какво време ще трябва да вземете Вашето решение?
>
> Вие ще вземате всяко от Вашите решения с времево ограничение. Това означава, че ще имате по 10 секунди за всяко от решенията.
>
> **Time delay**
>
> За какво време ще трябва да вземете Вашето решение?
>
> Вие ще вземате всяко от Вашите решения с времево забавяне. Това означава, че ще трябва да изчакате 15 секунди преди да вземете всяко от Вашите решения.

The text depended on the contest type condition:

> **In-group contests**
>
> Какъв ще бъде опонентът Ви в този рунд?

> Вие ще играете играта срещу група от етнически роми.
>
> **Out-group contests**
>
> Какъв ще бъде опонентът Ви в този рунд?
>
> Вие ще играете играта срещу група от етнически българи.

The remainder of the text on the screenshot remained the same across all conditions.

D.6.4 Decision views

Contribution Decision

In each round, players had to make a contribution decision (see a sample in Figure D.7).

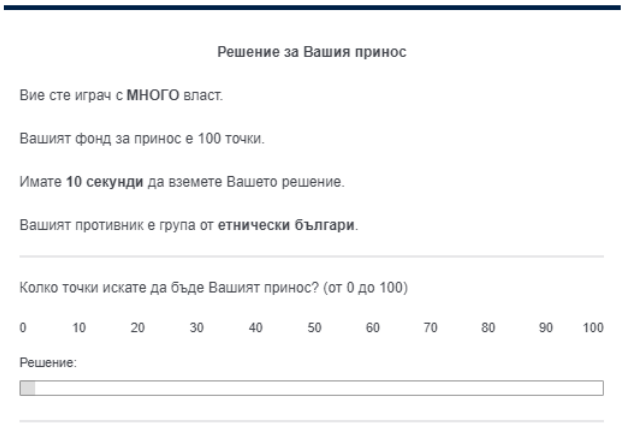


Figure D.7: Contribution decision view for Experiment 4b

The text varied dependent on the player type variable:

> **High-power player**
>
> Вие сте играч с МНОГО власт.
>
> **Low-power player**
>
> Вие сте играч с МАЛКО власт.
>
> **Egalitarian players**
>
> RANK IS NOT MENTIONED

The text varied dependent on the time constraint variable:

> **Time pressure**
>
> Имате 10 секунди да вземете Вашето решение.
>
> **Time delay**
>
> Трябва да изчакате 15 секунди преди да вземете Вашето решение.

The text varied dependent on the contest type variable:

> **In-group**
>
> Вашият противник е група от етнически българи.
>
> **Out-group**
>
> Вашият противник е група от етнически роми.

The remainder of the text on the screenshot remained the same across all conditions.

Resistance Decision

In each round, players also had to make a resistance decision (see a sample in Figure D.8).

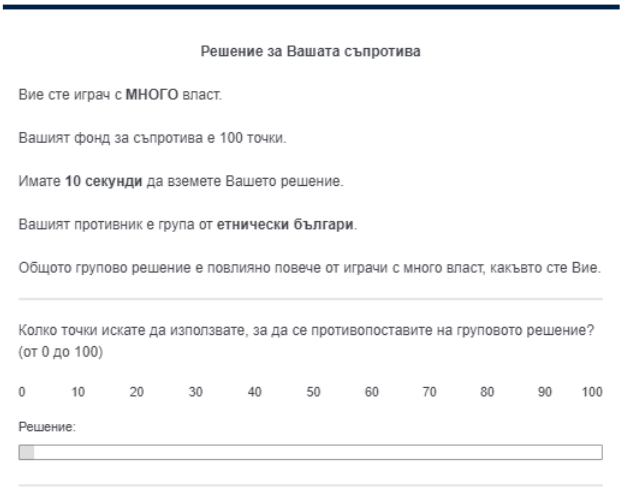


Figure D.8: Resistance decision view for Experiment 4b

The text varied dependent on the player type variable:

> **High-power player**
>
> Вие сте играч с МНОГО власт.

> **Low-power player**
>
> Вие сте играч с МАЛКО власт.
>
> **Egalitarian players**
>
> RANK IS NOT MENTIONED

The text varied dependent on the time constraint variable:

> **Time pressure**
>
> Имате 10 секунди да вземете Вашето решение.
>
> **Time delay**
>
> Трябва да изчакате 15 секунди преди да вземете Вашето решение.

The text varied dependent on the contest type variable:

> **In-group**
>
> Вашият противник е група от етнически българи.
>
> **Out-group**
>
> Вашият противник е група от етнически роми.

The text varied dependent on the player type variable:

> **High-power player**
>
> Общото групово решение е повлияно повече от играчи с много власт, какъвто сте Вие.
>
> **Low-power player**
>
> Общото групово решение е повлияно по-малко от играчи с малко власт, какъвто сте Вие.
>
> **Egalitarian player**
>
> Общото групово решение е повлияно по равно от всички играчи в групата.

The remainder of the text on the screenshot remained the same across all conditions.

Group decision

Finally, in each round, players also had to make a group decision (see a sample in Figure D.9).

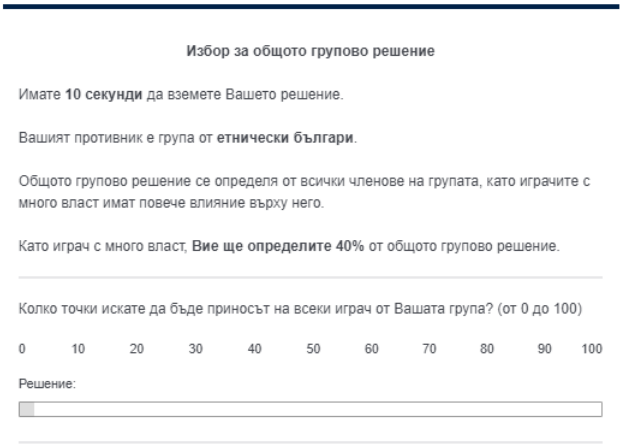


Figure D.9: Group decision view for Experiment 4b

The text varied dependent on the time constraint variable:

> **Time pressure**
>
> Имате 10 секунди да вземете Вашето решение.
>
> **Time delay**
>
> Трябва да изчакате 15 секунди преди да вземете Вашето решение.

The text varied dependent on the contest type variable:

> **In-group**
>
> Вашият противник е група от етнически българи.
>
> **Out-group**
>
> Вашият противник е група от етнически роми.

The text varied dependent on the system type variable:

> **Hierarchical groups**
>
> Общото групово решение се определя от всички членове на групата, като играчите с много власт имат повече влияние върху него.
>
> **Egalitarian groups**
>
> Общото групово решение се определя от всички членове на групата.

The text varied dependent on the player type variable:

> **High-power players**
>
> Като играч с много власт, Вие ще определите 40% от общото групово решение.

> **Low-power players**
>
> Като играч с малко власт, Вие ще определите само 10% от общото групово решение.
>
> **Egalitarian player**
>
> Както всеки играч от Вашата група, Вие ще определите 25% от общото групово решение.

The remainder of the text on the screenshot remained the same across all conditions.

D.7 Models for Experiment 4b

For all models in Experiment 4b I removed the correlations between the random slopes and the interaction between the random-effects variables to simplify the structure of the model. This allowed for a successful execution without convergence errors.

D.7.1 Contribution model

```
## model specification

contribution ~ player_type*contest_type*constraint*gender*outgroup_attitude +

                    (1 + contest_type+constraint | id)
```

Table D.11: LME model of contribution in Experiment 4b. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
player type	2.17	2, 253.75	0.116	0.011
contest type	4.02	1, 252.05	0.046 *	0.002
constraint	0.05	1, 248.2	0.819	< 0.001
gender	0.25	1, 253.9	0.615	< 0.001
outgroup attitude	1.53	1, 253.9	0.217	0.004
player type:contest type	1.20	2, 251.43	0.304	0.001
player type:constraint	0.10	2, 247.7	0.908	< 0.001
contest type:constraint	0.22	1, 248.19	0.639	< 0.001
player type:gender	0.81	2, 253.75	0.446	0.004
contest type:gender	2.42	1, 252.05	0.121	0.001
constraint:gender	0.57	1, 248.2	0.453	< 0.001
player type:outgroup attitude	0.09	2, 253.75	0.916	< 0.001
contest type:outgroup attitude	5.88	1, 252.05	0.016 *	0.003
constraint:outgroup attitude	0.04	1, 248.2	0.841	< 0.001
gender:outgroup attitude	1.21	1, 253.9	0.273	0.003
player type:contest type:constraint	0.37	2, 247.48	0.689	< 0.001
player type:contest type:gender	0.45	2, 251.43	0.636	< 0.001
player type:constraint:gender	0.18	2, 247.7	0.836	< 0.001
contest type:constraint:gender	0.04	1, 248.19	0.834	< 0.001
player type:contest type:outgroup attitude	2.33	2, 251.43	0.099 +	0.002
player type:constraint:outgroup attitude	0.18	2, 247.7	0.834	< 0.001
contest type:constraint:outgroup attitude	1.27	1, 248.19	0.261	< 0.001
player type:gender:outgroup attitude	6.46	2, 253.75	0.002 **	0.031
contest type:gender:outgroup attitude	6.23	1, 252.05	0.013 *	0.003
constraint:gender:outgroup attitude	0.19	1, 248.2	0.664	< 0.001
player type:contest type:constraint:gender	0.38	2, 247.48	0.681	< 0.001
player type:contest type:constraint:outgroup attitude	1.40	2, 247.48	0.25	0.001
player type:contest type:gender:outgroup attitude	0.17	2, 251.43	0.843	< 0.001
player type:constraint:gender:outgroup attitude	0.13	2, 247.7	0.877	< 0.001
contest type:constraint:gender:outgroup attitude	0.05	1, 248.19	0.83	< 0.001
player type:contest type:constraint:gender:outgroup attitude	0.24	2, 247.48	0.784	< 0.001

Table D.12: EMM contrasts of contribution for player type by contest type in Experiment 4b. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	contest type	EMM	SE	DF	t-ratio	p	es
egalitarian vs. high-power	in-group	-5.69	4.21	254.94	-1.35	0.369	-0.33
egalitarian vs. low-power	in-group	-7.53	4.03	251.61	-1.87	0.15	-0.44
high-power vs. low-power	in-group	-1.84	4.61	253.63	-0.40	0.916	-0.11
egalitarian vs. high-power	out-group	-8.49	4.26	250.10	-1.99	0.116	-0.50
egalitarian vs. low-power	out-group	-4.48	4.11	254.27	-1.09	0.522	-0.26
high-power vs. low-power	out-group	4.01	4.70	255.69	0.85	0.67	0.23

Table D.13: EMM contrasts of contribution for gender by player type and out-group attitudes in Experiment 4b. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	player type	outgroup attitude	EMM	SE	DF	t-ratio	p	es
female vs. male	egalitarian	negative	-4.47	5.67	251.64	-0.79	0.431	-0.26
female vs. male	high-power	negative	-3.81	6.73	254.56	-0.57	0.572	-0.22
female vs. male	low-power	negative	14.03	7.05	264.42	1.99	0.048 *	0.82
female vs. male	egalitarian	positive/neutral	-1.63	7.37	250.74	-0.22	0.826	-0.09
female vs. male	high-power	positive/neutral	12.52	10.41	254.27	1.20	0.23	0.73
female vs. male	low-power	positive/neutral	-26.42	9.26	250.03	-2.85	0.005 **	-1.54

Table D.14: EMM contrasts of contribution for player type by gender and contest type in Experiment 4b. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	gender	outgroup attitude	EMM	SE	DF	t-ratio	p	es
egalitarian vs. high-power	female	negative	-8.14	5.21	252.26	-1.56	0.263	-0.47
egalitarian vs. low-power	female	negative	-14.22	5.37	254.93	-2.65	0.023 *	-0.83
high-power vs. low-power	female	negative	-6.08	5.80	255.72	-1.05	0.548	-0.35
egalitarian vs. high-power	male	negative	-7.48	7.10	253.93	-1.05	0.544	-0.44
egalitarian vs. low-power	male	negative	4.28	7.28	261.73	0.59	0.827	0.25
high-power vs. low-power	male	negative	11.76	7.83	261.87	1.50	0.292	0.69
egalitarian vs. high-power	female	positive/neutral	-13.45	7.06	252.10	-1.90	0.139	-0.78
egalitarian vs. low-power	female	positive/neutral	5.36	6.70	254.32	0.80	0.703	0.31
high-power vs. low-power	female	positive/neutral	18.80	7.80	254.73	2.41	0.044 *	1.10
egalitarian vs. high-power	male	positive/neutral	0.70	10.62	253.52	0.07	0.998	0.04
egalitarian vs. low-power	male	positive/neutral	-19.43	9.75	248.44	-1.99	0.116	-1.13
high-power vs. low-power	male	positive/neutral	-20.13	11.54	251.32	-1.74	0.191	-1.17

Table D.15: EMM contrasts of contribution for contest type by gender and out-group attitudes in Experiment 4b. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	gender	outgroup attitude	EMM	SE	DF	t-ratio	p	es
in-group vs. out-group	female	negative	0.75	1.99	257.00	0.38	0.707	0.04
in-group vs. out-group	male	negative	-1.95	2.75	272.80	-0.71	0.479	-0.11
in-group vs. out-group	female	positive/neutral	0.54	2.59	245.81	0.21	0.834	0.03
in-group vs. out-group	male	positive/neutral	12.16	3.83	243.58	3.18	0.002 **	0.71

D.7.2 Expected net benefit model

```
## model specification

expected_net_benefit ~ player_type*contest_type*constraint*gender*outgroup_attitude +

                              (1 + contest_type+constraint | id)
```

Table D.16: LME model of expected net benefit in Experiment 4b. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
player type	2.88	2, 254	0.058 +	0.015
contest type	0.48	1, 254	0.487	< 0.001
constraint	0.42	1, 254	0.517	< 0.001
gender	0.43	1, 254	0.513	0.001
outgroup attitude	0.60	1, 254	0.441	0.002
player type:contest type	1.07	2, 254	0.343	< 0.001
player type:constraint	0.28	2, 254	0.758	< 0.001
contest type:constraint	0.19	1, 254	0.665	< 0.001
player type:gender	0.93	2, 254	0.396	0.005
contest type:gender	0.27	1, 254	0.603	< 0.001
constraint:gender	0.36	1, 254	0.548	< 0.001
player type:outgroup attitude	0.82	2, 254	0.444	0.004
contest type:outgroup attitude	1.24	1, 254	0.266	< 0.001
constraint:outgroup attitude	0.06	1, 254	0.803	< 0.001
gender:outgroup attitude	0.05	1, 254	0.825	< 0.001
player type:contest type:constraint	0.34	2, 254	0.716	< 0.001
player type:contest type:gender	0.13	2, 254	0.878	< 0.001
player type:constraint:gender	0.60	2, 254	0.55	< 0.001
contest type:constraint:gender	0.34	1, 254	0.563	< 0.001
player type:contest type:outgroup attitude	0.12	2, 254	0.885	< 0.001
player type:constraint:outgroup attitude	2.16	2, 254	0.118	0.002
contest type:constraint:outgroup attitude	2.14	1, 254	0.144	< 0.001
player type:gender:outgroup attitude	0.00	2, 254	0.997	< 0.001
contest type:gender:outgroup attitude	3.84	1, 254	0.051 +	0.002
constraint:gender:outgroup attitude	1.32	1, 254	0.252	< 0.001
player type:contest type:constraint:gender	0.58	2, 254	0.558	< 0.001
player type:contest type:constraint:outgroup attitude	0.24	2, 254	0.789	< 0.001
player type:contest type:gender:outgroup attitude	0.80	2, 254	0.45	< 0.001
player type:constraint:gender:outgroup attitude	1.10	2, 254	0.335	< 0.001
contest type:constraint:gender:outgroup attitude	0.24	1, 254	0.621	< 0.001
player type:contest type:constraint:gender:outgroup attitude	0.95	2, 254	0.387	< 0.001

Table D.17: EMM contrasts of expected net benefit for player type by contest type in Experiment 4b. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

contrast	contest type	EMM	SE	DF	t-ratio	p	es
egalitarian vs. high-power	in-group	10.25	5.55	254.00	1.84	0.157	0.47
egalitarian vs. low-power	in-group	6.64	5.34	254.00	1.24	0.428	0.31
high-power vs. low-power	in-group	-3.61	6.08	254.00	-0.59	0.824	-0.17
egalitarian vs. high-power	out-group	13.60	5.19	254.00	2.62	0.025 *	0.63
egalitarian vs. low-power	out-group	3.49	4.99	254.00	0.70	0.764	0.16
high-power vs. low-power	out-group	-10.11	5.69	254.00	-1.78	0.179	-0.47

D.7.3 Expected adjusted contribution model

```
## model specification

expected_contribution_adj ~ system_type*contest_type*constraint*gender*outgroup_attitude +

                                    (1 + contest_type+constraint | id)
```

Table D.18: LME model of expected adjusted contribution in Experiment 4b. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
system type	11.14	1, 258	< 0.001 ***	0.028
contest type	8.79	1, 258	0.003 **	0.004
constraint	0.03	1, 258	0.873	< 0.001
gender	0.05	1, 258	0.817	< 0.001
outgroup attitude	0.11	1, 258	0.742	< 0.001
system type:contest type	0.02	1, 258	0.887	< 0.001
system type:constraint	0.03	1, 258	0.865	< 0.001
contest type:constraint	0.29	1, 258	0.588	< 0.001
system type:gender	0.79	1, 258	0.374	0.002
contest type:gender	2.25	1, 258	0.135	< 0.001
constraint:gender	0.30	1, 258	0.583	< 0.001
system type:outgroup attitude	0.07	1, 258	0.788	< 0.001
contest type:outgroup attitude	2.40	1, 258	0.122	0.001
constraint:outgroup attitude	4.18	1, 258	0.042 *	0.002
gender:outgroup attitude	0.07	1, 258	0.797	< 0.001
system type:contest type:constraint	0.51	1, 258	0.477	< 0.001
system type:contest type:gender	0.69	1, 258	0.407	< 0.001
system type:constraint:gender	0.02	1, 258	0.892	< 0.001
contest type:constraint:gender	2.10	1, 258	0.148	< 0.001
system type:contest type:outgroup attitude	1.86	1, 258	0.174	< 0.001
system type:constraint:outgroup attitude	0.06	1, 258	0.814	< 0.001
contest type:constraint:outgroup attitude	0.66	1, 258	0.419	< 0.001
system type:gender:outgroup attitude	0.06	1, 258	0.813	< 0.001
contest type:gender:outgroup attitude	5.24	1, 258	0.023 *	0.002
constraint:gender:outgroup attitude	3.88	1, 258	0.05 *	0.002
system type:contest type:constraint:gender	0.86	1, 258	0.354	< 0.001
system type:contest type:constraint:outgroup attitude	0.00	1, 258	0.998	< 0.001
system type:contest type:gender:outgroup attitude	0.38	1, 258	0.539	< 0.001
system type:constraint:gender:outgroup attitude	0.03	1, 258	0.866	< 0.001
contest type:constraint:gender:outgroup attitude	5.74	1, 258	0.017 *	0.002
system type:contest type:constraint:gender:outgroup attitude	1.94	1, 258	0.165	< 0.001

D.7.4 Resistance model

```
## model specification

resistance ~ player_type*contest_type*constraint*gender*outgroup_attitude +

    (1 + contest_type+constraint | id)
```

Table D.19: LME model of resistance in Experiment 4b. Significance levels are represented as + for p < 0.1, * for p < 0.05, ** for p < 0.01, and *** for p < 0.001.

Term	F	DF	p	Rsq
player type	1.16	2, 252.74	0.314	0.006
contest type	0.71	1, 250.92	0.401	< 0.001
constraint	0.45	1, 238.73	0.503	< 0.001
gender	0.31	1, 253	0.58	< 0.001
outgroup attitude	0.91	1, 253	0.34	0.002
player type:contest type	0.67	2, 249.92	0.512	< 0.001
player type:constraint	0.64	2, 237.81	0.527	< 0.001
contest type:constraint	0.22	1, 243.72	0.638	< 0.001
player type:gender	0.64	2, 252.74	0.529	0.003
contest type:gender	0.07	1, 250.92	0.79	< 0.001
constraint:gender	0.85	1, 238.73	0.356	< 0.001
player type:outgroup attitude	1.68	2, 252.74	0.188	0.009
contest type:outgroup attitude	0.08	1, 250.92	0.776	< 0.001
constraint:outgroup attitude	0.25	1, 238.73	0.615	< 0.001
gender:outgroup attitude	0.30	1, 253	0.587	< 0.001
player type:contest type:constraint	0.25	2, 242.56	0.781	< 0.001
player type:contest type:gender	0.30	2, 249.92	0.743	< 0.001
player type:constraint:gender	0.62	2, 237.81	0.539	< 0.001
contest type:constraint:gender	0.00	1, 243.72	0.966	< 0.001
player type:contest type:outgroup attitude	0.07	2, 249.92	0.935	< 0.001
player type:constraint:outgroup attitude	0.57	2, 237.81	0.568	< 0.001
contest type:constraint:outgroup attitude	0.28	1, 243.72	0.599	< 0.001
player type:gender:outgroup attitude	0.12	2, 252.74	0.885	< 0.001
contest type:gender:outgroup attitude	0.19	1, 250.92	0.661	< 0.001
constraint:gender:outgroup attitude	0.23	1, 238.73	0.635	< 0.001
player type:contest type:constraint:gender	0.49	2, 242.56	0.616	< 0.001
player type:contest type:constraint:outgroup attitude	0.35	2, 242.56	0.705	< 0.001
player type:contest type:gender:outgroup attitude	0.64	2, 249.92	0.528	< 0.001
player type:constraint:gender:outgroup attitude	1.38	2, 237.81	0.253	0.001
contest type:constraint:gender:outgroup attitude	0.12	1, 243.72	0.729	< 0.001
player type:contest type:constraint:gender:outgroup attitude	2.60	2, 242.56	0.077 +	0.002

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