Peaceful Alternatives to Asymmetric Conflict

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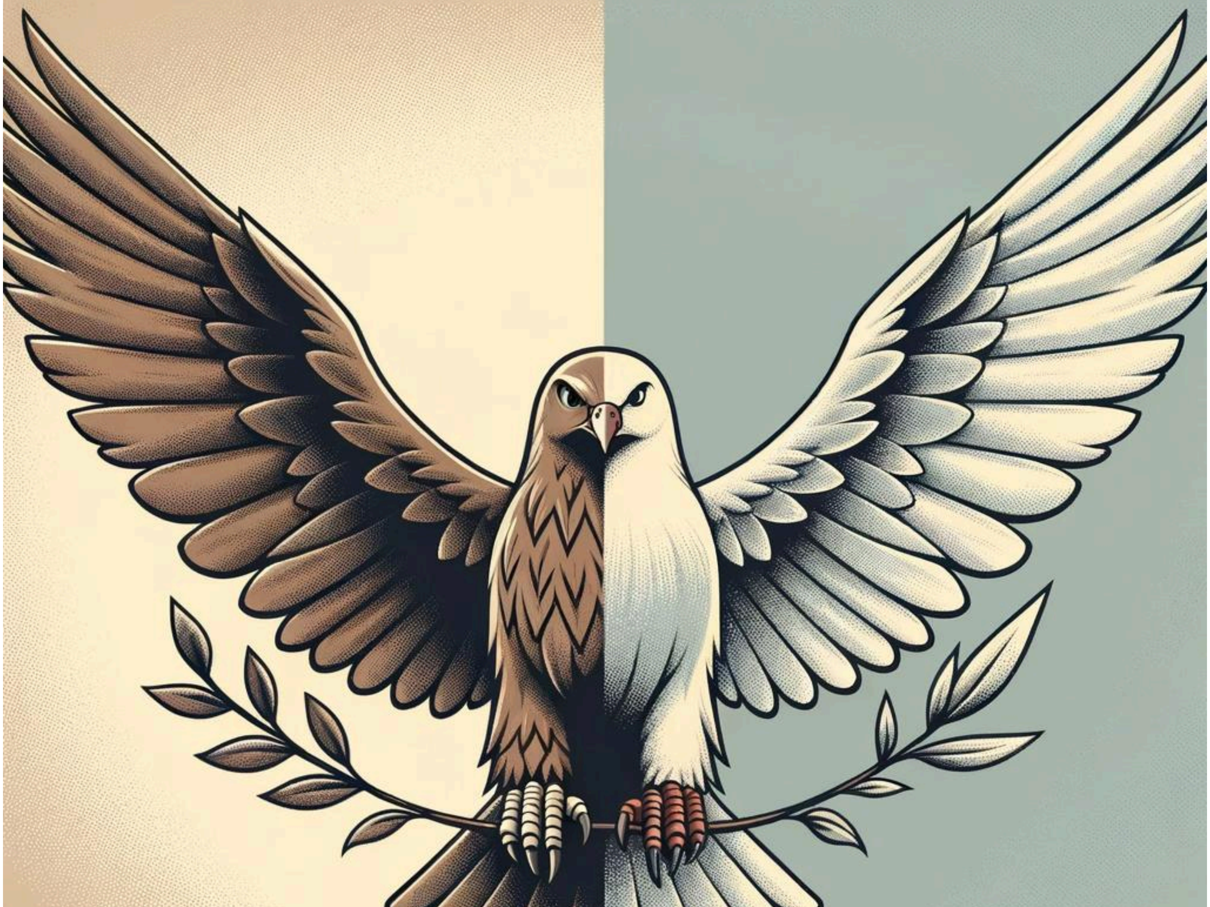

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Chapter 1 - Introduction

Conflict is a fundamental part of human society, with consequences that can reverberate through history. From interpersonal squabbles to international wars, conflict has the power to shape the trajectory of individuals, groups, and nations. Within groups, conflict can disrupt and reorder social hierarchies, resolve or ferment wealth inequality, and overturn existing social norms. Between groups, conflict shapes populations, the dissemination of goods and ideas, the formation of (group) identities, and can lead to longstanding intergenerational grievances between peoples.

Conflict often arises when one party wants something that another party tries to prevent (De Dreu & Gross, 2019). Indeed, from predator-prey dynamics in the animal kingdom (Packer & Ruttan, 1988; Bailey et al., 2013), to hostile take-overs in industry (Schwert, 2000), to military invasions (De Dreu et al., 2016), conflict often involves the asymmetric struggle between an attacking and defending party. While recent experimental work (De Dreu et al., 2015, 2016, 2019, 2021; Gross et al., 2022; Rojek-Giffin et al., 2019; Romano et al., 2022) has shed light on many dynamics of such asymmetric conflict, a key question remains: how can we resolve or reduce such conflicts, and specifically, how can we demotivate an attacking party from aggression? Indeed, if we were to understand the internal logic and underlying motivations of asymmetric conflict and find interventions that reduce attacker aggressiveness, we could close in on ways to actually prevent (asymmetric) conflict to emerge in the first place.

In this dissertation, I explore how the introduction of peaceful alternatives to create and increase wealth impacts the emergence and intensity of asymmetric conflict and its consequences using theoretical models and controlled laboratory studies. I proceed as follows: First, I review the relevant literature on the experimental study of (asymmetric) conflict using economic games. Second, I outline and summarize the three empirical chapters of this dissertation. Lastly, I discuss general conclusions and give an outlook on further research.

1. Literature Review

The study of conflict using experimental games

Scholars wanting to study (group) conflict are faced with various difficulties. Real world conflict often is highly complex, involving complicated entanglements between participating individuals and environmental factors, leading to the challenge of controlling for confounding variables and establishing causal relationships. Additionally, conflicts involving violence are both rare and, due to their nature, hard to access for researchers, such that most field research has been conducted in specific contexts such as sports (e.g., Szymanski, 2003) or organizations (e.g., Prendergast, 1999).

The experimental study of conflict using games of strategy can help to overcome some of these problems. Experimental games are stylized models of behavior, including clearly defined sets of players, decision strategies and pay-offs. If implemented experimentally they involve real interactions between participants, (often but not always) avoidance of deception, and, importantly, monetary incentives in order to render decisions making consequential. As with other experimental paradigms, experimental games allow researchers to test theoretical predictions about conflict without confounding effects and endogeneity issues.

In addition, economic games offer some distinct advantages. Research on games originated from their theoretical study, in particular with the development of *game theory* (Von Neumann & Morgenstern, 2007). As such, there exists a comprehensive mathematical framework that allows researchers to analyze interactive situations and to make precise theoretical predictions for the behavior of rational players “in equilibrium”. Rationality implies that players have consistent preferences over a set of clearly defined choices and make decisions (even in the face of complexity) to maximize their own utility. While many assumptions underlying rational decision making have been called into question (Camerer, 1999), equilibrium predictions can nonetheless serve as useful benchmarks against which to compare observed behavior. In addition, most experimental games simplify real-life situations by abstracting from specific contextual details and attempt to model (only) the critical features of the phenomena under question. If done well, a game can therefore be used to transcend specific examples, capture their structural essence, and lead to a generalized understanding of the phenomena.

Given these strengths, economic theory and experiments have been highly successful in studying human cooperation and coordination (e.g., van Dijk & De Dreu, 2021), and shed light on many related phenomena such as social preferences (Van Lange et al., 2013), cooperative beliefs (Pruitt & Kimme, 1977), (emotion) signaling (e.g., Ellingsen et al., 2018, Vranceanu & Dubarth, 2019), reputation and gossip (Sommerfeld et al., 2007, Shank et al., 2019), and (in)direct reciprocity (Axelrod & Hamilton, 1981; Balliet et al., 2011).

Contest Games

Although a variety of games of strategy have been designed to study conflict and cooperation, a specific subset of games, so called contests, is of particular interest here as they model situations in which collective rationality dictates participants to avoid conflict, and self-interest dictates some competitive action is required. Specifically, a contest can be defined as a situation in which two or more contestants have the opportunity to invest costly and non-recoverable resources in order to affect the probability of winning a prize (Konrad, 2009). While originally developed to study lobbying for government contracts (hence the alternative name of “rent seeking”-games; Tullock, 1988), contest games are highly versatile and can be used to model any competition of individuals or groups over a prize. Indeed, researchers have applied contest models to study a wide range of conflicts between (groups of) individuals, ranging from elections (e.g., Millner and Pratt, 1989; Davis and Reilly, 1998), to litigation and “lawfare” (e.g., Coughlan and Plot, 1997, Dechenaux and Mancini, 2008), to strategic behavior in wars (e.g., Borel, 1921; Linster et al., 2001).

The two most prominent contest models are Tullock’s (1988) rent-seeking contest and all-pay auctions (Hillman and Riley, 1989, Baye et al., 1996). These two differ in their contest success function, that is, the way in which contest success is decided. Tullock contests determine the winner of the contest probabilistically, using the ratio of individual player inputs, whereas all-pay auctions decide the outcome deterministically - the contestant with the highest investment wins the contest. As alluded to above, contest games are characterized by a tension between individually rational and socially optimal behavior. In the Tullock contest, for example, the socially optimal (pareto-efficient) level of investment for the competing parties is zero, since all resources spend on conflict are non-recoverable. In equilibrium, however, rational players will always spend some of their resources on conflict. Since all players engage in the same level of conflict the probability of each player winning the conflict stays constant, making conflict investments both unproductive and socially wasteful.

Both models have been extensively studied in controlled laboratory settings. Experiments are often concerned with variations in contest design - for example, by varying the decisiveness of the player’s relative investments (Millner and Pratt, 1989; Potters et al., 1998) or by investigating a sequential decision-making protocol (e.g., Weimann et al., 2000; Sheremeta, 2010). One striking and consistent result emerging from this literature is the significant overinvestment into conflict compared to equilibrium benchmarks - contestants behave far more aggressively than they should, assuming rational play (Dechenaux et al., 2015; Sheremeta, 2014).

While conflict frequently arises over exogenous prizes, often individuals or groups compete over endogenously produced wealth and possessions. This is recognized by so-called "Guns-vs-Butter"-models that focus on the trade-off between production and conflict as two fundamental, yet distinct modes of economic activity (Haavelmo, 1954; Pareto, 2014). For example, Hirshleifer (1988, 1991) and Skaperdas (1992) model this choice as a contest in which two parties divide their initial endowment between an investment in (joint) productive activity and efforts at appropriating the produced wealth. As with other contest models, equilibrium analysis indicates that, while peaceful production is socially optimal, rational players will engage in some level of inefficient and wasteful conflict. Hirshleifer (1991) studies wealth inequality and demonstrates that, in contrast to the popular notion that "the rich get richer, and the poor get poorer", under most conditions, the initially less well-endowed side improves its position compared to its better endowed opponent (the "Paradox of Power"). Experimental results (Durham et al., 1998) largely confirm theoretical predictions - interestingly, however, without finding the typical overinvestment, suggesting that the option for production attenuates the irrational aggressiveness characteristic of pure contest games.

Intergroup Conflict

Although the discussed models have been applied to the study of group conflict, there is a crucial limitation: Groups are made up of individual members, and within-group dynamics play an important role in the initiation, escalation, and settlement of intergroup conflict (De Dreu & Triki, 2022). For example, groups engaging in conflict face problems of cooperation: All group members benefit if they coordinate their actions and act collectively when in competition with another group. However, individual contributions are costly (including, in the case of violent conflict, sacrificing group members' lives), creating a strong incentive to defect and to free-ride on other group members' contributions (Bornstein, 2003).

To study these dynamics, and especially the tension between free-riding by not participating in conflict and making costly contributions that escalates wasteful conflict, researchers have modelled intergroup conflict as two-level contests, with individual players nested in groups which, in turn, are nested within an (adversarial) intergroup system. For instance, researchers have extended Tullock's rent-seeking contest to a group-based version, the Group Lottery Contest (Abbink, 2010). Group members of two groups compete by contributing to local group pools on which basis the likelihood of winning an exogenous prize is determined. Each winning group member then receives an equal share of the prize. Studies observe high levels of intergroup conflict and, as with 2-player contests, demonstrate substantial overinvestment compared to equilibrium predictions (Abbink, 2010, 2012; Sheremeta and Zhang, 2010; Ahn et al., 2011). Indeed, the introduction of institutions that are typically observed to reduce free-riding within groups – including leadership (De Dreu et al., 2016), punishment (Abbink, 2010; De Dreu et al., 2016), and communication (Cason et al., 2012, 2017) – only exacerbates this effect: Group members free-ride less which results in more wasteful and inefficient over-aggressiveness between groups and an overall escalation of conflict.

Further evidence that people will engage in intergroup competition if beneficial to the ingroup comes from research on the Intergroup Prisoner's Dilemmas Game (Bornstein, 1992, see Bornstein, 2003 for a review). Group members have to decide whether to contribute to a public good which offers a return but simultaneously inflicts a cost on the other group. Despite the harmful effect on the other group, contributions are substantial. In fact, compared to an otherwise structurally identical public good, group members are almost twice as likely to cooperate if negative externalities are present (Bornstein & Ben-Yossef, 1994). An extended version - the Intergroup Prisoner's Dilemma-Maximizing Difference game - introduces an additional within-group public good to each group. Contributions to both the in-group and the between-group pool serve in-group welfare equally, and the only reason for investing in the between-group pool, thereby imposing a negative externality, is to punish the other group. Experimental results indicate that, if given the choice, groups prefer to contribute to the purely cooperative within-group pool, but invest also, albeit to a lesser and less consistent degree, into the competitive between-group pool (e.g., De Dreu, 2010, Halevy et al., 2008, 2012; Schweda et al., 2019, Weisel & Böhm, 2015, Weisel & Zultan, 2022).

The experimental research therefore suggests that if negative interdependencies between groups exist, group members will contribute substantially to intergroup conflict, exceeding the amount of contribution that would be expected from rational players. Nonetheless, groups prefer peaceful (parochial) cooperation if options for such are present. A key question is therefore under which conditions intergroup relations change from peaceful (within-)group cooperation to intergroup conflict. Recently, De Dreu et al. (2020) have suggested that endogenously (e.g., through group growth and expansion) or exogenously (e.g., through natural disasters) created carrying capacity stress can serve as a cause for groups to engage in intergroup conflict.

Carrying capacity stress occurs when a groups' demand for resources exceeds the available supply and falls short of what the group needs or is accustomed to (Read & LeBlanc, 2003; Tyler et al., 2021). Indeed, De Dreu et al. (2022) demonstrate experimentally that carrying capacity stress, induced through a risk of destruction of group members' endowments, triggers out-group aggression and (attempts at) appropriating resources from others. An accompanying analysis of archival data on interstate conflicts likewise showed that states were more likely to engage in warfare when their economic and climatic conditions were more volatile and unpredictable prior to conflict.

Asymmetric Conflict and the Attacker-Defender Contest

Not all conflicts occur between two parties competing over an exogenous prize. Structurally, many, if not most, conflicts occur between a party that wants something that another party tries to prevent from happening (De Dreu & Gross, 2019). Often one of the parties has an initial claim to a resource, giving rise to an asymmetric conflict structure (Grossman and Kim, 1995). From predator-prey dynamics in the animal kingdom (Packer & Ruttan, 1988; Bailey et al., 2013), to hostile take-overs in the business world (Schwert, 2000), to military invasions of one state by another, conflict is often a struggle between an "attacking" and "defending" party. Indeed, two-thirds of 2000 interstate conflicts since 1816 were between a revisionist aggressor - seeking a change in territory, policy, or government - and a non-revisionist defender (De Dreu et al., 2016).

Recent work (Chowdhury & Topolyan, 2016; De Dreu et al., 2015, 2016, 2019, 2021; Gross et al., 2022; Rojek-Giffin et al., 2019; Romano et al., 2022) has investigated such asymmetric conflict more closely utilizing both economic analysis and experimental methods. The Attacker-Defender Contest (henceforth AD-C; see De Dreu & Gross, 2019, for a review) consists of two (or more) players, one in the role of an "attacker", one in the role of "defender". Attackers can invest (part of) their endowment into attack and attempts at appropriation, defenders can invest (part of) their endowment to try to prevent such appropriation. If the attacker's investment exceeds that of the defender, the attacker will appropriate all of the defenders remaining resources. Investments are always wasted so both the attacker and defender have to balance the costs of conflict against the prospect of an uncertain gain (for attacker) or loss (for defender).

Results from multiple experimental studies (e.g., De Dreu et al., 2015; De Dreu et al., 2016; Rojek-Giffin et al., 2020) indicate that defenders spend both more and more frequently on defense than attackers on aggression. As a result, attacks are only successful about 30% of the time - closely resembling success rates in interstate warfare, corporate hostile takeovers, and group-hunting predators (De Dreu, Gross, et al., 2016). Nonetheless, since attackers spend overall less on conflict while profiting from appropriation at least some of the time, they realize substantially higher earnings than defenders. As with other conflict games, both attackers and defenders overinvest into conflict when compared to equilibrium predictions.

2. Outline of Thesis

This thesis presents three empirical chapters that explore how to reduce asymmetric conflict and, specifically, how to demotivate attackers and prevent aggression against defenders. The following sections provide a detailed outline of the empirical chapters.

Chapter 2

When faced with the threat of aggression, a defending party can respond in several ways. They can adapt by fighting, they can attempt to flee or migrate away from the aggressor, or they can try to “befriend” or appease a potential aggressor with gifts and related payments. “Befriending” is a risky strategy but can also be successful. For example, the British Government unsuccessfully attempted to appease Nazi Germany by accepting the annexation of the Sudetenland from Czechoslovakia, resulting in the invasion of Poland in 1938 (Ripsman & Levy, 2008). On the other hand, the Chinese tributary system is an example of how tributary payments ensured stable relations between China and its neighboring states for long periods of Chinese history (Kang, 2010). In chapter 2, two experiments investigate if defenders will make use of the option to transfer resources and if such transfer will be effective in reducing aggression.

Standard economic theory predicts that attackers will exploit any resource transfers and lower their attack investments only to account for the defenders' diminished capacity of defense (Méder et al., 2022). A rational defender, in turn, should anticipate this and refrain from any transfer of resources. From a behavioral perspective, however, there is reason to assume that defenders will make use of the option to transfer. Indeed, work on bargaining and reciprocal tension reduction suggests that conciliatory messaging and making small unilateral concessions can be effective in building trust, reducing punitive actions and increasing cooperation (Boyle and Lawler, 1991; Large, 1999, Lawler et al., 1999, Osgood, 1962), including in prisoner's dilemmas (Lindskold & Han, 1988) and other bargaining games (De Dreu, 1995). On the attackers' side the notion that defender transfers can appease attackers is based on a general norm of reciprocity (Cialdini, 1984; Cialdini & Goldstein, 2004; Gouldner, 1960; Regan, 1971) - attackers may feel compelled to "return the favor" by not attacking. This possibility would, for example, resonate with extant work on trust games in which trustees have no rational interest in returning anything, and yet abide by some implicit norm of reciprocity and back-transfer a non-trivial amount (Berg et al., 1995; Chaudhuri and Gangadharan, 2007; Cox, 2004).

We conducted two experimental studies to investigate the use of resource transfers as a strategy for reducing aggression. In the first study, we compared the AD-C with the Transfer Attacker-Defender Contest (TAD-C). In the TAD-C, participants go through an additional stage before the contest where the defenders can transfer some of their endowment to the attackers. The defenders can defend themselves with whatever resources they have left after the transfer, while the attackers can use their endowment and any transferred resources for investments in attack. In the second study, we employed a strategy method of the TAD-C for both attackers and defenders to replicate our results and better understand participants' decision-making. We tested the expectations that defenders have towards attacker aggression after transfer and the influence of social value orientation and probability of transfer on attacker aggression.

Results from study 1 showed that defenders in the TAD-C used the option to transfer resources, presumably as a means of appeasing attackers. A comparison of AD-C and TAD-C showed that the transfer option was effective in reducing overall conflict. Both attackers and defenders invested less in conflict in the TAD-C, but attackers benefited disproportionately. The added wealth inequality in the TAD-C was explained through the voluntary transfer of resources from defenders to attackers. Transfer had other shortcomings as well. While defenders significantly lowered their defense spending when they transferred resources, attackers did not significantly decrease their aggression, leading to higher attacker success and increased earning disparity in favor of attackers in the trials involving transfer.

In study 2, we replicated some of the findings from the interactive experiment. In particular, defenders made use of the option for peaceful transfer and expected attackers to aggress them less when they did, lowering their defense investment. Attackers exploited this by using transferred MU to increase aggression at lower levels of transfer and adjusting their conflict spending according to the defenders' remaining endowment at higher levels of transfer. This effect was moderated by social value orientation, especially at lower levels of transfer.

Overall, our results suggest that asymmetric conflict indeed can be alleviated by providing the defending party with an alternative to transfer (some of their) resources to the attacker. Results were mixed, however, since some attackers exploit transfers by aggressing the defender, a behavior (in part) moderated by social value orientation. In chapter 3, we explore another approach to reducing conflict in the AD-C, in particular, by providing outside options for wealth production.

Chapter 3

To advance their own social and economic prosperity, humans can invest in the production of goods and services, or in the appropriation of goods and services provided by others (Haavelmo, 1954; Pareto, 2014). In Chapter 3, we explore whether adding production opportunities to an asymmetric contest can reduce attackers' attempts at appropriation, and how these production opportunities affect conflict dynamics overall.

Scholars in political economy and conflict studies (Maoz & Russett, 1993a; Rousseau, Gelpi, Reiter, & Huth, 1996; Wittman, 2000) have suggested that providing individuals or groups with alternative ways to produce wealth may reduce the temptation to engage in aggression. For instance, providing criminal offenders with job opportunities has been shown to decrease their likelihood of committing crimes such as burglary (Becker, 1968; Uggen & Shannon, 2014). Similarly, firms with more innovative research and development activities are more likely to engage in friendly rather than hostile takeovers (Bena & Li, 2014). However, the idea is not without critics (Luce, 2015) and evidence for it is mixed. In fact, creating opportunities for economic production may actually increase the probability and intensity of conflict by incentivizing aggressors to appropriate produced wealth (cf. the "natural resource curse"; Brunnschweiler & Bulte, 2009; and the "paradox of power"; Hirshleifer, 1988, 1991; Olsson, 2007; van der Ploeg, 2011).

We conducted a game-theoretic analysis and an experiment to investigate the effects of production opportunities on asymmetric conflict. For both the analysis and the experiment, we compared the AD-C to an extended version called the PAD-C (Production Attacker-Defender Contest). In the PAD-C, players have the option to invest some of their endowment in production in order to achieve a payoff. In order for a player's production investment to be successful, it must meet or exceed a certain threshold. For our theoretical analysis, we examined how the predictions for equilibrium play changed based on the production threshold and production payoff. In the experiment, we compared the AD-C to the PAD-C to test the predictions generated by our model. To keep the PAD-C unpredictable for human participants, the production threshold varied randomly across rounds.

Our game-theoretical analysis shows that having opportunities for economic production can reduce conflict expenditures and promote equality in wealth distribution. However, the ease with which production can be achieved (the “production threshold”) plays a role in determining the level of aggression and inequality. When production thresholds are low, our model predicts that there will be less aggression and more equal wealth distribution. On the other hand, when production thresholds are high and difficult to meet, our model predicts that there will be more predatory behavior and unequal wealth distribution favoring attackers. The ease with which successful production can be realized is therefore a key factor in the emergence or decrease of predatory conflict.

Our behavioral experiment largely confirmed the first prediction of our theoretical model: providing opportunities for economic production can reduce attacker aggression and overall conflict. In the PAD-C, individuals did not invest less frequently in attack and defense, but their investments were of overall lower magnitude. In other words, conflict became less intense when participants had alternative means to accumulate wealth other than through predatory aggression. In addition, we observed that individuals were often successful at production, and as a result, contestants in the PAD-C became wealthier than those in the AD-C. However, the unchanged frequency of conflict limited the defenders’ resources available for production and defenders were unable to accumulate as much wealth as their attackers. As a result, wealth disparities increased in favor of attackers.

In sum, chapter 3 explores the effects of providing contestants in an asymmetric conflict with an alternative means to generate wealth through production. Our findings show that such production opportunities can help to reduce attacker aggression and the intensity of conflict. In Chapter 4, we further investigate the impact of production opportunities on asymmetric conflict, specifically in a group setting.

Chapter 4

To sustain and support themselves and their members, groups need to cooperate on club goods in order to produce food, goods or services (such as healthcare and education). Groups can also cooperate on aggressing and appropriating resources from other groups or - if targeted by such aggression - on defending themselves. In chapter 4, we examine if and how carrying-capacity stress on the (peaceful) production of resources via a club good is related to the emergence of outgroup aggression and intergroup conflict.

Carrying-capacity stress emerges when group members' individual and collective needs and desires exceed resource availability (see e.g., Read & LeBlanc, 2003; Tyler et al., 2021) or when resource supply and returns from club goods become erratic and unpredictable (Bloom, 2009; Duncan, 1972; Ellis, Figueredo, Brumbauch & Schlomer, 2009). Individuals dislike unpredictability and invest cognitive and physical effort to reduce uncertainty and create stable and predictable futures (Kruglanski, Pierro, Mannetti, & De Grada, 2006; Landay, Kay & Whitson, 2015). In response to carrying-capacity stress, individuals may decrease their contributions to local club goods, leading to a classic "tragedy of the commons" in which groups are worse off collectively (e.g., Gustafsson, Biel & Gärling, 2000; Messick et al., 1988; Rapoport et al. 1992; Van Dijk et al., 1993; Wit & Wilke, 1998). However, external threats and environmental disasters can also increase within-group commitment and solidarity (De Dreu, Gross & Reddmann, 2022; Hogg, 2002; Barth, Masson, Fristsche & Ziemer, 2018), as well as willingness to contribute to group-benefitting club goods (Lojowska et al., 2022). Indeed, individuals may seek alternative ways to sustain their group, such as expanding their territory and engaging in hostile attacks on neighboring out-groups. If true, we would expect carrying-capacity stress not only to reduce cooperation on local club goods with uncertain returns, but also to increase participation in collective aggression against out-groups.

To examine the possibility that individuals in groups under carrying-capacity stress invest energy in competing for resources with other groups, we created an experimental model in which six individuals were nested in two groups of three. Within each group, individuals were given an endowment from which they could make contributions to a local club good or to conflict. To operationalize and manipulate carrying-capacity stress, we made the group benefit from club good provision either predictable (Mean Per Capita Return, MPCR = 1.5 on every trial) or unpredictable (MPCR being 0.5 in half of the trials and 2.5 in the other half). Hence, in the one condition, in-group cooperation created a predictable amount of wealth, shared across all group members whereas in the other condition, in-group cooperation could sometimes lead to a very low and sometimes to a very high return for the group. In addition to their club goods, individuals could also contribute to a contest with the other group. This contest was designed as a group attacker-defender game. Thus, in addition to their local club good, participants could contribute towards out-group attack or, in the other group, in-group defense. This setup provided attackers with an alternative means to obtain resources for their group. Participants played the game for 80 decision trials, with 4 counterbalanced blocks (of 20 trials each) manipulating the (un-)predictability of attackers' and defenders' local club good. Across trials, the expected value (assuming risk neutrality) of the groups' club goods was the same in all treatments, but the predictability of the returns differed.

Despite the expected utility of club good contributions being the same under standard economic theory, experimental results indicate startling differences in behavior for both attackers and defenders under uncertainty. Under the uncertain condition, attackers substantially lowered their club good provision, decreased coordination, and more frequently opted to invest nothing. In turn, they demonstrated improved conflict coordination and increased their overall investments in out-group attacks. In fact, both uncertain returns in the attacker club good and certain returns in the defender club good were associated with increased investment into attack. Defenders, however, adapted their defense investments to the attackers' aggression. As a result, appropriation attempts were unsuccessful, did not contribute to higher attacker earning, and thus increased attack investments under attacker uncertainty were ultimately wasted. Despite no change in the expected value of their choices, because of the breakdown in contribution to their club good, attackers earned less under uncertainty than when club good returns were certain. Attackers also earned less than they could have if they wasted less resources on conflict and simply kept more resources to themselves. Defenders' earnings likewise declined when either their own or the attacker's club goods was uncertain. Thus, an uncertain environment increased wasteful conflict, leading to a decline in the overall social welfare, particularly when the attacker groups faced an uncertain club good.

Overall, chapter 4 complements chapter 3 by demonstrating that production opportunities can be a successful means of reducing asymmetric conflict in a group setting. Importantly, however, a productive club good needs to provide stable, predictable returns. Under uncertain conditions, club good cooperation breaks down, and group members put (a part of) their resources into out-group aggression, leading to overall more wasteful conflict, and reduced earnings for both attackers and defenders.

3. Conclusions

The present dissertation uses theoretical models and experiments to investigate if and how asymmetric conflict can be reduced or resolved, and, in particular, how the attacking party can be demotivated from aggression. Across three empirical chapters I provide first answers to this question. In chapter 2, I introduce the option for peaceful resource transfers from defenders to attackers. In chapter 3, I provide contestants with an alternative to generate wealth in the forms of (risky) production opportunities. In chapter 3, I extend such productions opportunities to a group setting and investigate how (un-)predictable returns to a local club good effects cooperation and inter-group conflict. While experimental designs and manipulations across these chapters differ, findings allow for the following generalizations:

1. *Both attackers and defenders use peaceful alternatives for wealth generation if they are provided.*

In chapter 2, I show that defenders use the option for peaceful resource transfers at least some of the time. In chapter 3, both attackers and defenders invest into production opportunities if they are provided. And in chapter 4, attackers and defenders cooperate on productive local club goods, especially if the returns from these club goods are predictable (rather than unpredictable).

2. *Peaceful alternatives for wealth generation reduce attackers' aggression, but do not fully eradicate conflict.*

The introduction of transfer options (Chapter 2), the provision of production opportunities (Chapter 3) and of productive club goods with predictable (rather than unpredictable) returns (Chapter 4) reduce attackers' aggression significantly. Across all studies I also observe that defenders simply adjust their defense investments to attacker behavior, resulting in an overall decrease in conflict spending. Reductions in conflict were mostly explained through significant reductions in the magnitude and either no (Chapter 3) or only modest (Chapter 2 and 4) decreases in the frequency of conflict investment. In other words, contestants continue to engage in conflict, but conflicts become less intense.

3. *Because less resources are spent on wasteful conflict, the introduction of peaceful alternatives for wealth creation is of mutual benefit.*

Across all three chapters, we observe that both parties increase their overall earnings when peaceful alternatives to conflict are present. In all studies, earnings increase due to reduced investments into wasteful and destructive conflict. In chapter 3 and 4, both parties additionally benefit from the provided opportunities for peaceful wealth generation.

4. *Peaceful alternatives for wealth creation benefit attackers more, paradoxically leading to more wealth inequality compared to when peaceful alternatives are absent.*

Due to defenders adjusting their defense investments to attackers' aggression, in all three chapters attack success rates stay constant across manipulations, excluding changes in resource appropriation as a cause of increased attacker earnings. In chapter 2, the increased inequality favoring attackers can be explained exclusively due to resource transfers increasing the attackers' (and decreasing the defenders') payoffs. In chapter 3 and 4, the threat of aggression results in defenders spending both more and more frequently on conflict then attackers. Compared to attackers, this restrains defenders in their ability to take advantage of production opportunities. Attackers, on the other hand, can more efficiently allocate their resources between conflict and production when production facilities are present (Chapter 3) or contribute more to a club good with predictable returns (Chapter 4), and thus realize higher earnings. Attackers' strategically advantaged position thus helps them to take greater advantage of the conflict alternatives that we provide.

5. Peaceful alternatives to wealth creation eliminate over-investment in conflict and align contestants' behavior more closely with theoretical predictions based on rational selfish play.

While not the primary focus of this dissertation, it is noteworthy that in the two chapters that include equilibrium analyses, providing participants with peaceful alternatives reduces conflict over-investment usually found in contest games (Dechenaux et al., 2015; Sheremeta, 2014). In chapter 2, game theory posits that rational defenders should not make use of the option to transfer, and thus predictions are the same for the AD-C and its extended version. The behavioral data, in contrast, show strong conflict overinvestment in the AD-C while investments in the extended version approach theoretical benchmarks. In chapter 3, the introduction of production opportunities changes theoretical predictions compared to those for the AD-C. Nonetheless, I again observe significant conflict overinvestment in the AD-C while participants' behavior in the extended version including production opportunities closely aligns with the theoretical analysis.

Discussion

Preventing a conflict by appeasing a potential aggressor can work in some cases but as demonstrated in chapter 2, comes with a significant risk of emboldening the aggressing party and being exploited. Indeed, examples of failed appeasement strategies abound in history and its risks have been well demonstrated by previous scholarly work (Treisman, 2004). Providing opportunities for production and peaceful cooperation, as indicated by chapters 3 and 4, might therefore be a more fruitful means to reduce the intensity of conflict in general and predatory aggression in particular. Depending on the context, policy makers aiming to reduce conflict might therefore focus on creating such opportunities. For example, policy makers wanting to reduce crime could focus on providing labor market opportunities such as improved access to education, (re-)employment programs, and wage increases (Draca and Machin, 2015). Governments and international institutions wanting to reduce violent conflict and war should aim at promoting economic development, for example, through foreign aid (cf. Nielsen et al., 2012) and by creating conditions conducive to economic growth (Hegre & Nygård, 2015).

My research demonstrates that alternatives to conflict reduce but do not eliminate conflict. Indeed, as has previously been argued "individuals, groups or nations are rarely if ever, totally at war or totally at peace" (Hirshleifer, 1988). Instead, resources are divided amongst productive and conflictual activity, especially if a longer time horizon is taken into account (Hirshleifer, 1988, 1995). While this finding at first might appear somewhat pessimistic, it must not necessarily be seen this way. The reduction (rather than eradication) of conflict can make a big difference and might in some cases even be desirable: An athletic competition is better than a knife fight, a clash in court is better than one on the street, and a “cold” war is preferable to a “hot” one.

As illustrated, being aggressed (or the threat of being aggressed) necessitates investing scarce resources into defense which impedes investment into production. Indeed, similar dynamics have been observed across disciplines. Plants face a trade-off between defending against herbivores (through a variety of physical and chemical means) and other functions related to evolutionary fitness. For example, it has been demonstrated that contact with herbivores can reduce plant growth (see Züst and Agrawal, 2017, for a recent review). Likewise, companies in less competitive markets are more innovative and productive (Aghion, Bloom, Blundell, Griffith, & Howitt, 2005; Chemmanur & Tian, 2018; Conti, 2014) and defense spending can have a detrimental effect on countries economic growth (Dunne and Tian, 2013).

Results for the “pure” attacker-defender contests in Chapter 2 and 3 replicate a typical finding of experimental contest games: Significant overinvestment into conflict relative to the standard Nash equilibrium benchmark (De Dreu et al., 2021; Sheremeta, 2013). In contrast, no such deviations from equilibrium could be found when adding peaceful alternatives in the form of transfer options (Chapter 2) or production opportunities (Chapter 3), a finding that is mirrored in the scarce experimental literature on “Guns-vs-Butter”-models (Durham et al., 1998). While the reason for over-investment in competitive environments is an open question (Dechenaux et al., 2015; Sheremeta, 2014), one interesting possibility is that humans, instead of maximizing absolute pay-offs as posited by game theory, are evolutionarily adapted to maximize pay-offs relative to the other party and therefore express spiteful preferences (Hamilton 1970; Hehenkamp, Leininger, and Possajennikov 2004; Leininger 2003; Frey and Stutzer, 2003). Thus, providing outside options might have provided attackers with an alternative means to maximize their pay-offs relative to the other party. This explanation would fit our observations that providing alternatives increased the overall inequality in favor of attackers.

Future Research

In my studies, attackers were in an advantaged position and therefore benefited more than defenders from the peaceful alternatives to conflict that were provided. Further experimental research could therefore examine ways in which to alleviate conflict while archiving more equitable outcomes.

In chapter 4, I show that carrying capacity stress can lead to a break-down in in-group cooperation on a productive club good and a (partial) switch to out-group aggression. The interaction between environmental and economic conditions, within-group dynamics, and intergroup cooperation and competition is an understudied area, and experimental researchers have only begun to explore it. For example, it has been suggested that economic threat and turmoil gives rise to authoritarian leadership structures (e.g., Miller, 2017). Further research could explore if and how uncertain economic conditions affect support for leadership institutions, and if, in turn, such institutions might increase outgroup aggression. In a similar vein, researchers could explore the use of punishment if club good returns turn (un-)certain. It would be interesting to investigate whether groups under (un-)certainty would increase punishment not only to prevent free-riding, but also, depending on the condition, to curb club good contributions vs outgroup aggression.

Economic games abstract from specific contextual details of a situation and attempt to model the critical features of the phenomena under question, hoping to achieve a generalized understanding. Economic experiments are also limited, however, by using such an artificial and stylized environment. De Dreu et al. (2016, 2022) show that conflict dynamics found in the experimental study of the AD-C extend to other data such as corporate takeovers and interstate disputes. Further research could validate my findings by integrating them with data from real-world settings. For example, it would be interesting to see if countries or companies in a “defending” position exhibit higher defense spending (e.g., investment in marketing rather than new product development) and negative economic growth and how inequality between attacking and defending parties is affected.

Chapter 2 - Resource Transfers Reduce but Do Not Eliminate Conflict

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Abstract

When faced with the threat of aggression, a defending party can attempt to “pay off” and appease its attacker through the transfer of resources. Whether defenders make such payments and whether and how resource transfers mitigate aggression and conflict is an unresolved question. Historical anecdote and related experimental work suggest that appeasement and conciliatory gestures can be effective, but also run considerable risk of being exploited. We hypothesized that defenders would make such transfers in the attempt to appease the other party, and that in response attackers would decrease their aggression, reducing overall conflict. Two experiments using an extended version of the Attacker-Defender Contest demonstrate that defenders use resource transfers as an appeasement strategy, expect reduced aggression from the attackers, and, in turn, decrease their own conflict investment. Responses by the attackers were more varied: While conflict investment overall decreased, only some attackers reduced their aggression, others used the transferred resources to escalate the conflict and exploit the defender. Our second experiment reveals that these individual differences are partly explained by attackers’ social value orientation, with prosocial attackers being more prone to reduce their conflict investment upon receiving a transfer than selfish attackers. Our findings extend previous work on conflict resolution and bargaining strategies and highlight the critical role of expectations and individual differences. They also suggest that strategic appeasement can be effective in reducing aggression, yet its success is crucially dependent upon a correct assessment of the opposing party's interests and values.

Keywords: conflict, attacker-defender contest, cooperation, conflict resolution

Introduction

Social conflict emerges when individuals or groups invest resources to advance their interests at a cost to those of others. Examples include civil wars, terrorist attacks, or hostile takeovers in business. Anticipating aggressive attacks can lead to protective defense including pre-emptive strikes, thus easily creating cycles of attacks and counter-attacks that are economically wasteful and emotionally taxing at both the individual and collective level (Abbink & De Haan, 2014; De Dreu & Gross, 2019; Halevy, 2012; Jervis, 1979).

To protect against the threat of being aggressed against, individuals and their groups sometimes have alternatives to reactive aggression – they can flee and migrate away from potential aggressors or, counterintuitively perhaps, try to "befriend" or appease potential aggressors with gifts and related payments. Whereas migration is costly but likely to reduce the threat of being attacked, whether and how effective making payments and transferring resources to potential aggressors is remains unknown. There is anecdotal evidence that such transfers happen, and can have appeasing consequences. For long periods in history, for example, states neighboring China paid tributes to Chinese emperors in exchange for not being invaded. Historians attribute long-term regional stability to this system of paying tributes (Kang, 2010). Likewise, at the height of the Cold War between the Soviet Union and the United States, scholars experimented with so-called Gradual Reduction of International Tension: antagonists could be enticed to reciprocate small and one-sided reductions in (nuclear) power, setting in motion a cycle of arms reduction without risking being overpowered (Linskold & Han, 1988; Osgood, 1962). Conversely, however, there is reason to expect such concessions to actually escalate conflict – defenders transferring resources to potential aggressors empower the latter comparatively and reduce the cost of attacking. For example, historians' debate whether Chamberlain's appeasement strategy to prevent Nazi Germany from invading Czechoslovakia in 1938 made it, in fact, easier rather than more difficult for Hitler to attack Czechoslovakia and, shortly thereafter, Poland (Ripsman & Levy, 2008).

While historical examples suggest that antagonists use appeasement with mixed results, little is known about the use and consequences of resource transfers in more mundane conflict and competitions among individuals or small groups. Our goal here is to fill this void. With two experiments on dyadic contests, we answer two open questions: (i) do agents under threat of attack voluntarily transfer resources to their potential aggressor, and (ii) if they do, what are the consequences of such transfers for conflict dynamics. Our experimental contests involve an attacker and a defender. Attackers can invest resources to capture those of their defender while defenders, simultaneously, can invest resources to prevent attacks to be successful. Prior to the contest, defenders but not attackers can decide to transfer some of their resources to their antagonist. We observe how conflict evolves over time when defenders can (vs cannot) transfer resources to their attacker, whether and with how much defenders transfer to their attacker, whether making transfers has an appeasing effect on attackers, and whether there are individual differences in how attackers respond to their defenders' transfers.

Resource Transfers from an Economic and Behavioral Perspective

The Attacker-Defender Contest models conflicts in which one side invests to capture the other side's resources, while the other side invests to protect its resources from being taken. While investing in conflict is collectively wasteful – resources invested are non-recoverable – it can be in the attacker's best interest to invest in attack (up to some point) and, therefore, in the defender's best interest to invest in defense (for formal analysis of the contest, see Methods; De Dreu & Gross, 2019; Meder, Gross & De Dreu, 2022).

To study the emergence and consequences of transfer payments, we add to the basic attacker-defender contest the possibility for defenders to transfer some of their resources to their attacker prior to conflict investment. Such payment reduces the defender's resources for defense and increases by the same amount the attacker's resources for attack. Assuming that, as in Standard Economic Theory, attackers and defenders are strictly concerned with maximizing payoff, making transfers should not be observed. A defending party should assume that attackers will act in their own rational self-interest and use transfer payments for attack. Additionally, giving away resources undermines the defenders' ability to defend against possible aggression. Making transfers is thus at odds with selfish payoff maximization among defenders and empowers attackers, which should lead to more rather than less conflict and more rather than fewer victories for attackers.

Relaxing the assumption of strict payoff maximization reveals not only that defenders may transfer resources to their potential aggressors, but also how receiving transfer payments may reduce conflict. As noted at the outset, early work on bargaining and reciprocal tension reduction suggests that small unilateral concessions can be effective in building trust, reducing punitive actions and increasing cooperation (Boyle and Lawler, 1991; Large, 1999, Lawler et al., 1999, Osgood, 1962). For example, Lindskold and Han (1988; De Dreu, 1995) showed that conciliatory messaging can foster cooperation in prisoner's dilemma and bargaining games, and Rubin and Brown (1975) argued that the use of promises in bargaining situations can lead to a general liking for the person making the promises, supporting the idea that conciliatory approaches can be effective in fostering cooperation.

The notion that defender transfers can appease attackers is based on a general norm of reciprocity (Cialdini, 1984; Cialdini & Goldstein, 2004; Gouldner, 1960; Regan, 1971)—attackers may feel compelled to "return the favor" by not attacking. Evidence for this possibility would resonate with extant work using trust games. In the trust game, an investor decides to transfer an amount to a trustee. The amount transferred is tripled, and the trustee can then return any amount to the investor. Whereas it is in the trustee's best interest not to return anything, ample research has shown that trustees abide by some implicit norm of reciprocity and back-transfer a non-trivial amount (Berg et al., 1995; Chaudhuri and Gangadharan, 2007; Cox, 2004). At both the psychological and neural level such back-transfers relate to the desire to avoid unequal distribution of resources (*viz*., inequality aversion; Bolton & Ockenfels, 2000; Fehr & Schmidt, 1999), adherence to a do-no-harm principle (Baron, 1995; also see De Dreu, Giacomantonio et al., 2019), and an aversion towards violating moral norms and disappointing others (*viz.*, guilt aversion; Battigalli & Dufwenberg, 2007; Charness & Dufwenberg, 2006; Chang et al., 2011).

Experiment 1: Overview and Hypotheses

Experiments as well as anecdotal observations suggest that, in contrast to Standard Economic Theory, individuals defending against possible aggression are willing to "appease" their antagonist by voluntarily transferring them resources. This is Hypothesis 1. Work on trust games and the neural and psychological underpinnings of (not) 'returning the favor' lend support to Hypothesis 2, that attackers receiving voluntary transfer from their defenders invest less in attack than those not receiving such payment. If true, and because investing in conflict is collectively wasteful, we should see that post-conflict wealth is higher when defenders have, versus not, possibilities to transfer resources to their potential attackers. We note, however, that such collective savings particularly favor attackers, who not only waste less on conflict but also receive resources from their defender. Put differently, when transfer payments are made and reduce conflict, attackers might end up wealthier.

We tested our hypotheses by comparing the standard Attacker-Defender Contest (De Dreu & Gross, 2019; henceforth AD-C) with the newly created Transfer Attacker-Defender Contest (henceforth TAD-C). In the AD-C, an attacker and a defender each enter the interaction with an endowment e. Players have to decide how much of their endowment to invest in attack (for the attacker, a) or in defense against such attack (for the defender, d).

While investments are always lost (hence, conflict is wasteful), the non-invested part of the players' endowment *e* may count towards their payoff. If the attacker's investment exceeds that of the defender, i.e., $a > d$, the attacker appropriates the defender's remaining endowment and adds it to her own. In contrast, if *d* is equal to or larger than *a*, defenders successfully defend and both players keep their remaining endowments. The attacker's payoff is therefore:

$$\pi_{Att}(a,d) = \begin{cases} e-a & if\ a \le d \\ 2e-a-d & if\ a > d \end{cases}$$

The defender's payoff is:

$$\pi_{Def}(a,d) = \begin{cases} e-d & if\ a \le d \\ 0 & if\ a > d \end{cases}$$

The TAD-C is a simple extension of the AD-C. Players go through an additional stage prior to the contest. In this stage, the defender can decide if and how much of their endowment they want to 'gift' to the other party – the amount of transfer *t,* constrained by the defender's endowment ($0 < t < e$). The attacking player is informed about this transfer, and, in the second stage, players proceed to play the AD-C as described. The defender can defend themselves with whatever resources they have left after the transfer in the first stage ($0 < d < [e - t]$). The attacker can use their endowment and whatever resources they have received in Stage 1 for investments towards attack ($0 < a < [e + t]$). Transfers in Stage 1 are thus risky, with no binding contract guaranteeing that attackers will lower or even avoid increasing their attack investment.

In the TAD-C, the attacker's payoff is therefore:

$$\pi_{Att}(a,d,t) = \begin{cases} e+t-a & if\ a \le d \\ 2e-a-d & if\ \ a > d \end{cases}$$

The defender's payoff is:

$$\pi_{Def}(a,d,t) = \begin{cases} e - t - d & if\ a \leq d \\ 0 & if\ a > d \end{cases}$$

Methods

Ethics and Participants. The experimental design and hypotheses were preregistered (https://aspredicted.org/K8D_GJ3) and approved by the Psychology Research Ethics Committee of Leiden University (Protocol #CEP 2021-05-28-xxx-V2-3261). Participants provided informed consent and received full debriefing upon conclusion of the study. We recruited 144 participants (83 female; age M = 29.30, SD = 10.03, range 18–69 years), resulting in 72 experimental dyads.

Experimental Procedures. Participants were recruited using prolific.co from which they were invited to a discord.com server. After they entered the server, the general rules and procedure of the experiment were explained to them, and the experimenter greeted them over a chat box. Once 4 participants had joined the server, they were provided with a link to the experiment. The experiment was designed using oTree (Chen et al., 2016). Throughout the experiment, participants could contact the experimenter over the discord.com chat box for questions.

The 4 participants were randomly assigned to two fixed dyads - playing either the AD-C or TAD-C - and within dyads either to the role of attacker or defender. Participants received extensive instructions on the experimental task, followed by comprehension questions to make sure that every participant understood the rules. All instructions used neutral language to avoid framing effects. Participants would then play the task for 15 trials in which both attacker and defender had 30 MU at their disposal at the start of each round. Between trials, participants received full feedback: In both AD-C and TAD-C, participants learned how much attackers and defenders invested into conflict, what outcome the conflict had, and how much both parties earned. In the TAD-C, participants additionally received information after Stage 1 of the contest on how many MU the defender had transferred to the attacker and how many MU both parties would have at their disposal at Stage 2. After the main task, all participants completed a series of questionnaires which were collected to answer research questions outside of the scope of the current paper and are therefore not further discussed. Finally, all participants were debriefed.

Participants were paid after completion of the study via the prolific.co platform. Participants received a 7.50 GBP participation fee and an additional performance-based payment. For the main task, the outcome of six randomly selected trials of decision-making were summed and then converted into GBP at a rate of 1 MU = 0.20 GBP.

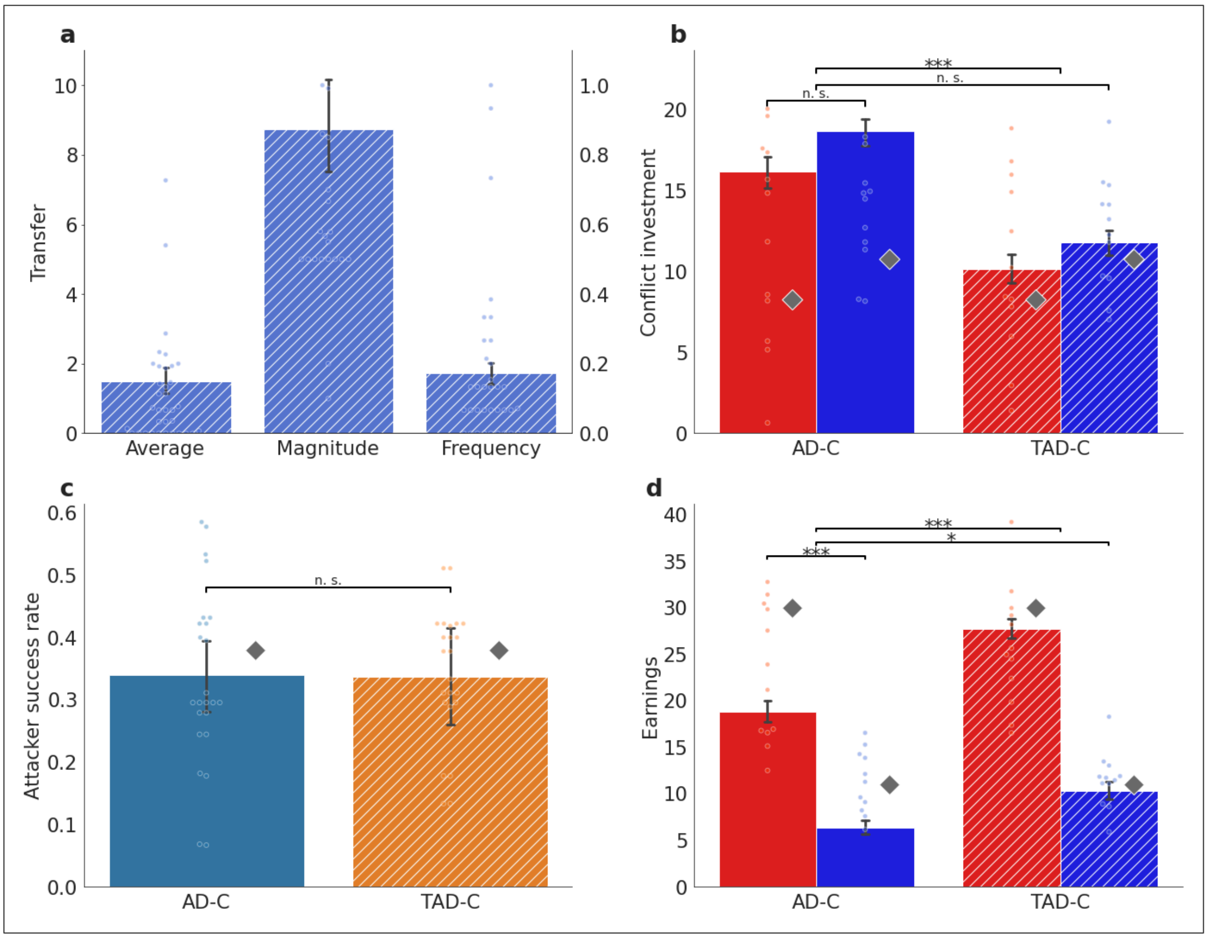
Results

Main Analysis Strategy. The data from our interactive experiment are hierarchically structured. For our main analysis (unless indicated otherwise), we therefore accounted for the resulting violation of independence of individual data points by fitting random intercept regression models with decisions nested within participants, nested within dyads. Predictors of our main model were *game* (TAD-C/AD-C), *role* (Defender/Attacker), and the interaction term. We performed our analyses using Python for data processing and plotting and R for model fitting (Team, 2016). Linear mixed models were fitted using the lme4 package (Bates et al., 2015) and *p*-values were obtained using the lme4 extension package lmerTest (Kuznetsova et al., 2017).

Main effects of AD-C versus TAD-C. Confirming Hypothesis 1, defenders in the TAD-C made use of the option to transfer in stage 1 of the game, spending on average 1.83 MU (i.e., ~7% of their MU; Intercept = 1.83, $p < .001$; Table 1; Figure 1a) per round. Further analysis revealed that defenders transferred relatively infrequently, with transfers made in 20.12% of trials (approximately every fifth trial; Intercept = 0.20, $p < .001$; Table 1; Figure 1a). However, the “magnitude” of these transfers (calculated by excluding trials with transfer equal to 0) was substantial with an average of 8.82 MU (approximately ⅓ of the MU at their disposal; Intercept = 8.82, $p < .001$; Table 1; Figure 1a).

Figure 1

Conflict decisions and game-theoretic benchmarks in AD-C and TAD-C



Note. (a) Defenders' average transfer and transfer magnitude (in MU) and transfer frequency, (b) conflict investments (in MU), (c) attacker success rate, and (d) earnings (in MU) in the AD-C (solid) vs TAD-C (dashed) for attackers (red) and defenders (blue). Shown are mean values (bars), standard errors (± 1 SE), aggregated investment by subject (dots), and Nash equilibrium predictions (Diamonds). Contrasts are significant at $^{*}p < .05$, $^{**}p < .01$, and $^{***}p < .001$.

Table 1

Results of linear random intercept mixed models for defenders in the TAD-C condition predicting outcome variables related to defender transfer (study 1). The intercept estimates the mean difference of these variables from 0.

Dependent Variable	Predictor	Estimate (*b*)	Test statistic (*t*)	*p*
Defender transfer	(Intercept)	1.83	4.31	< .001
Defender transfer magnitude	(Intercept)	8.82	12.12	< .001
Defender transfer frequency	(Intercept)	0.20	4.91	< .001

Note. Estimates for aggregated effect using linear mixed model with random effects *participant* and *dyad*.

In line with Hypothesis 2, a comparison between the AD-C and TAD-C revealed a significant reduction in conflict investment (*Game* coefficient = -5.59, $p < .001$). This effect was independent of role: Attackers and defenders invested similarly less in the TAD-C than in the AD-C (*Game* × *Role* coefficient = -1.05, $p = .597$; Table 2; Figure 1b). As a consequence, we found no between-game difference in attacker success rate (*Game* coefficient = -0.01, $p = .810$; Table 2; Figure 1c). In other words, while defenders made use of their option to ‘appease’ attackers, albeit infrequently, and reduced conflict expenditure on both sides, the presence of this option did not reduce the frequency with which attackers successfully exploited defenders.

Due to the savings in conflict spending, both attackers and defenders realized higher earnings in the TAD-C (*Game* coefficient = 8.58, $p < .001$). As anticipated, however, earning disparity favored attackers more in the TAD-C (*Game* × *Role* coefficient = -4.77, $p = .040$; Table 2; Figure 1d). In other words, whereas both attackers and defenders benefited in their personal earnings from the option of transfer, attackers benefited more. This interaction effect disappeared after subtracting the amount of transferred MU (stage 1) from the attackers’ earnings and adding it back to the defenders' payoffs (*Game* × *Role* coefficient = -1.72, p = .428; Table 2), indicating that the higher earning disparity in the TAD-C are explained by the MU voluntarily transferred by the defenders in Stage 1.

Table 2

Results of linear random intercept mixed models showing how the type of game (AD-C vs TAD-C) and role (attacker vs defender) impacts different outcome variables (study 1).

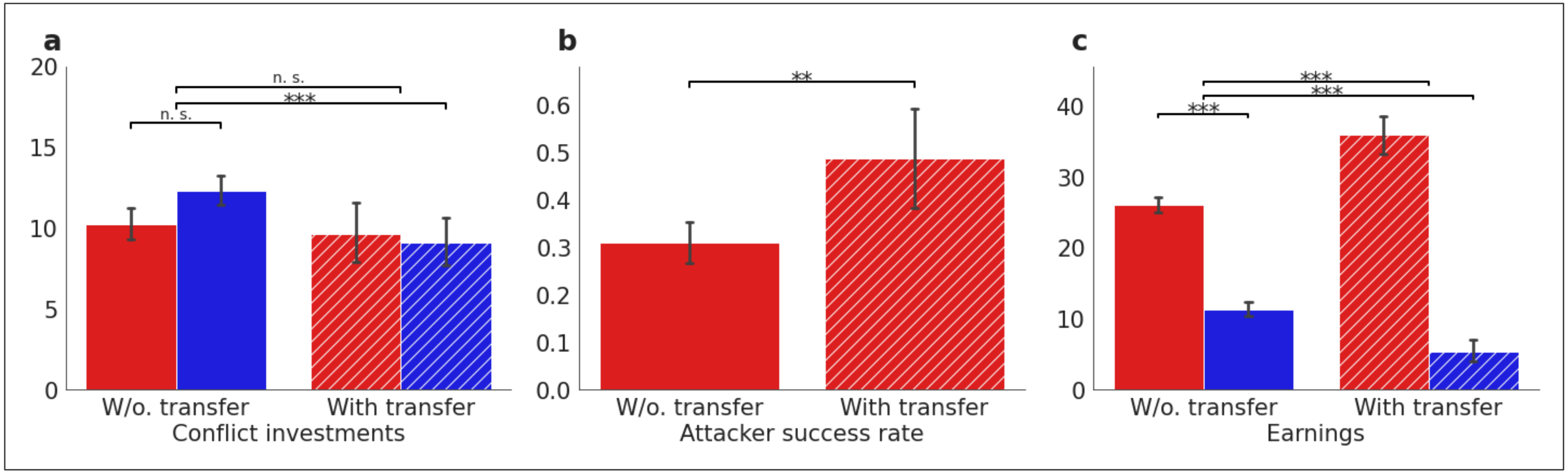
Dependent Variable	Predictor	Estimate (b)	Test statistic (t)	p
Conflict investment	(Intercept)	16.24	13.67	< .001
	Game: TAD-C	-5.59	-3.84	< .001
	Role: Defender	2.60	1.84	.069
	Game × Role	-1.05	-0.53	.597
MU kept	(Intercept)	13.77	11.16	< .001
	Game: TAD-C	7.16	4.59	< .001
	Role: Defender	-2.58	-1.70	.093
	Game × Role	-1.99	-0.93	.356
Attacker success rate	(Intercept)	0.35	12.07	< .001
	Game: TAD-C	-0.01	-0.24	0.81
Earnings	(Intercept)	18.78	14.78	< .001
	Game: TAD-C	8.58	5.20	< .001
	Role: Defender	-12.56	-7.75	< .001
	Game × Role	-4.77	-2.09	.040
Earnings (w/o transferred MU)	(Intercept)	18.78	15.19	< .001
	Game: TAD-C	7.00	4.46	< .001
	Role: Defender	-12.58	-8.19	< .001
	Game × Role	-1.72	-0.79	.428

Note. Estimates for aggregated effects using linear mixed model with random effects *participant* and *dyad*.

Comparing Trials with versus without Transfer. To gain more insight into how the option to transfer reduced conflict spending, we compared trials in which defenders did or did not make use of the transfer option in the TAD-C condition. This showed that defenders substantially lowered their defense spending in trials in which they transferred MU (*Transfer* coefficient = -4.44, $p < .001$; Table 3). Attackers, however, on average did not reduce their aggression after receiving (vs not) any transfer from their defender (*Transfer* coefficient = 0.61, $p = .587$; Table 3; Figure 2a). As a result, attackers on average invested into conflict slightly more than defenders when defenders paid some transfer and were more often victorious and earned more when defenders did transfer resources (*Transfer* coefficient = 0.17, $p = .006$; Table 3; Figure 2b; and *Transfer* x *Role* coefficient = -13.65, $p < .001$; Table 3; Figure 2c).

Figure 2

(a) Conflict investments (in MU), (b) attacker success rate and (c) earnings (in MU) for attackers (red) and defenders (blue) for trials without (solid) vs with (dashed) transfer in the TAD-C



Note. Shown are mean values (bars) and standard errors (± 1 SE). Contrasts are significant at *p < .05, **p < .01, and ***p < .001.

Table 3

Results of linear random intercept mixed models showing the effect of trials with vs without defender transfer, role (attacker vs defender), and their interaction on various outcome variables in the TAD-C condition (study 1).

Dependent Variable	Predictor	Estimate (*b*)	Test statistic (*t*)	*p*
Attacker conflict investment	(Intercept)	10.17	8.54	< .001
	Transfer: With	0.61	0.54	.587
Defender conflict investment	(Intercept)	12.51	12.40	< .001
	Transfer: With	-4.44	-4.29	< .001
Conflict investment	(Intercept)	10.17	9.20	< .001
	Transfer: With	0.60	0.55	.581
	Role: Defender	2.35	1.50	.136
	Transfer × Role	-4.76	-3.17	.001
Attacker success rate	(Intercept)	0.31	9.91	< .001
	Transfer: With	0.17	2.79	.006
Earnings	(Intercept)	26.18	22.56	< .001
	Transfer: With	8.84	6.37	< .001
	Role: Defender	-15.06	-9.18	< .001
	Transfer × Role	-13.65	-7.07	< .001

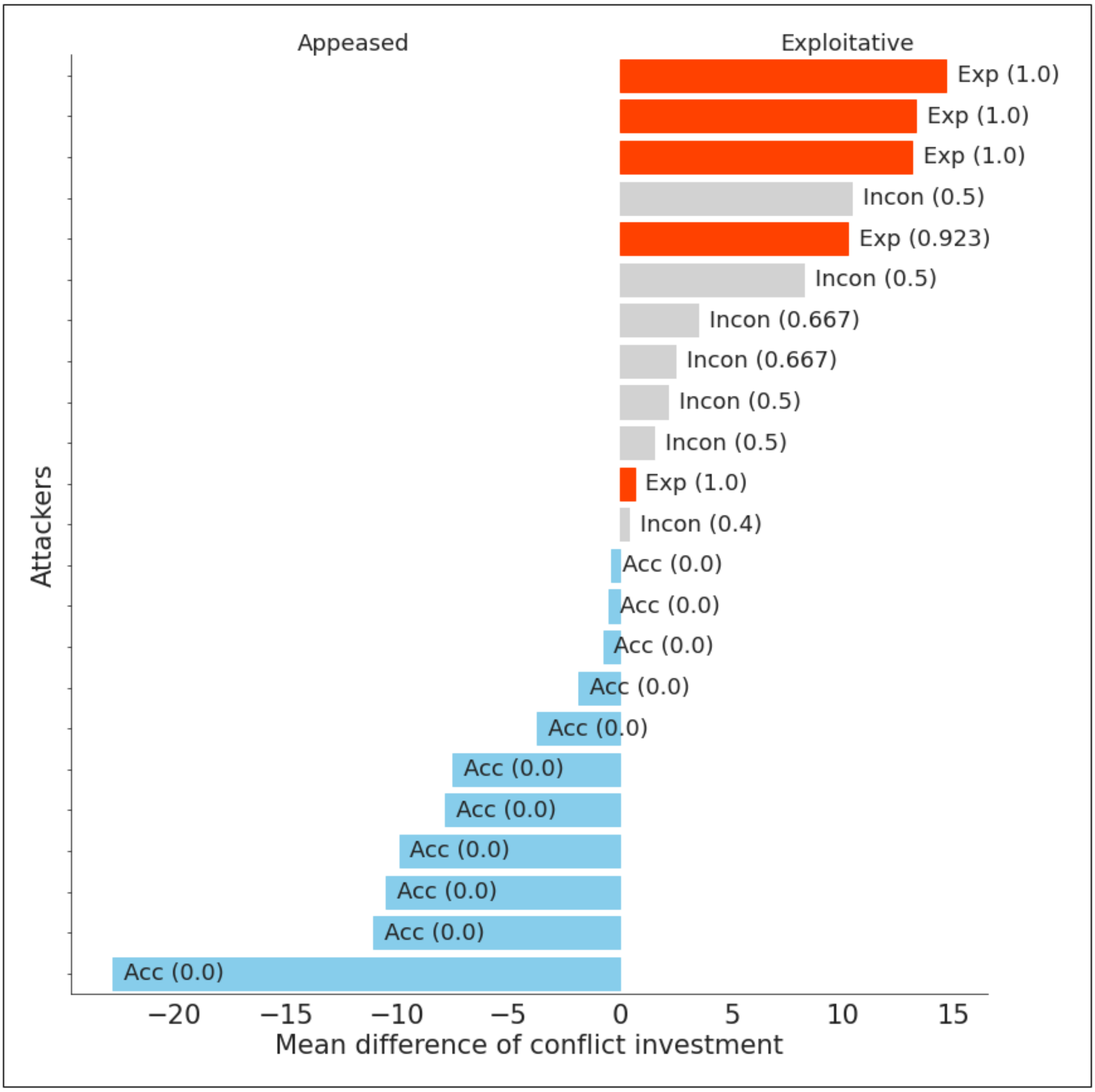
Note. Estimates for aggregated effects using linear mixed model with random effect *dyad*.

Analysis of Attacker Types. On average, attackers in the TAD-C did not lower their attack spending when defenders made transfers. What cannot be excluded, however, is that this average null-result conceals that some attackers respond to defender transfer with increased aggression and others are appeased and lower conflict investment. To examine this, we classified participants in the role of attacker as "exploitative" if they invested on average more in trials with transfer compared to their conflict investment in trials without transfer, and as "appeased" if they invested on average less in trials with transfer. To probe for consistency in such behavior across trials, we additionally classified attackers as "exploiters", "accepters", and "inconsistent" based on the frequency with which they invested either equal or more *or* less in trials with transfer than their average conflict investment in trials without transfer. Participants who invested as much or more into conflict when they received (vs not) transfers 75% or more of the time (i.e., the third quartile) were classified as consistent "exploiters". Participants who invested less than their without-transfer conflict average in 75% or more the trials (i.e., the first quartile) were labeled as "accepters", and the remaining 50% (i.e., the second quartile) as "inconsistent".

Of the 36 dyads in the TAD-C condition, 13 (36.11%) had defenders that did not make use of the option to transfer at all and were thus irrelevant for our analysis of attacker responses. Using the remaining 23 dyads, 12 attackers (52.17%) were classified as "exploitative", investing on average 6.71 MU more, and 11 attackers (47.83%) were classified as "appeased", investing on average 6.99 MU less in trials with (vs without) transfer. The classification of attackers by response frequency likewise supports a classification into types: 5 "exploiters" (21.74%) consistently invested more in trials with (vs without) transfer, 11 "accepters" (47.83%) consistently invested less, and the remaining 7 attackers (30.43%) were classified as “inconsistent.” There was strong overlap between the categories: All 11 "accepters" who frequently invested less in trials with (vs without) transfer also invested less in conflict on average, while the 5 "exploiters" who frequently invested more in trials with (vs without) transfer also invested more in conflict on average (see Figure 3).

Figure 3

Attacker types in the TAD-C



Note. Ordered bar plot displaying the mean difference in conflict investment for trials without vs with transfer for 11 "Appeased" and 12 “Exploitative” attackers. Labels and colors show the classification into "Exp(loiters)" (red), "Incon(sistent)" (grey), and "Acc(epters)" (blue) based on the frequency (in brackets) of investing an equal amount or more.

Discussion and Introduction to Experiment 2

Experiment 1 provided support for Hypothesis 1 that defenders transfer resources to their attackers. We found mixed support for Hypothesis 2 that attackers receiving (vs not) such transfers are appeased and reduce conflict investment. In fact, Experiment 1 revealed that some attackers used transfer payments to further exploit their defenders with increased aggressiveness, while others were appeased by payments and reduced conflict investments, as predicted. This qualified support for Hypothesis 2, born out of exploratory analyses, points to individual differences in social preferences. Our main goal with Experiment 2 was, therefore, to replicate and extend these findings, testing the prediction that attackers with selfish motivation respond to transfer payment with increased conflict investment, whereas those with prosocial motivation respond with reduced conflict investment.

Experiment 2 used a strategy method (Fehr and Fischbacher, 2004, Güth et al., 2001) for both attackers and defenders in which we elicited conditional behavior and manipulated beliefs and expectations (see below). We expected new support for Hypothesis 1 that defenders transfer part of their endowment to the attacker. As observed in Experiment 1, we also expected that defenders lower their conflict investment after making a transfer (vs not) and examined whether this is because defenders making a transfer also expect attackers to become less aggressive (H1a).

Methods

Ethics and Participants. The experimental design and hypotheses were preregistered (https://aspredicted.org/KNM_J9W) and approved by the Psychology Research Ethics Committee of Leiden University (Protocol #CEP 2022-05-06-xxx-V2-4009). Participants provided informed consent and received full debriefing upon conclusion of the study.

We recruited 241 participants (111 female; age M = 38.83, SD = 13.63, range 19–72 years), 120 for the attacker and 121 for the defender condition. Participants were recruited online using prolific.co from which they were provided with a link to the experiment. The experiment was implemented using the Qualtrics survey platform.

As is common for a sample collected in this way, data inspection revealed erratic response patterns for some of the participants, indicating low-effort or misunderstanding. In the attacker condition, participants were removed if they met either of the following two criteria: investing 10 MU or more than the defenders' remaining endowment after transfer (even though a single MU more than the defenders' remaining endowment would suffice for the attacker's victory) and failing four or more of the comprehension questions on their first attempt, *or* completing the study in less than 14 minutes and 45 seconds (half of the trimmed mean completion time).

For the defender condition, we removed participants if their conflict decisions were in stark contradiction to their expectations of attacker decisions. More specifically, if defenders overinvested 10 or more MU relative to their stated expectation of attacker conflict investment *or* underinvested 10 or more MU relative to their expectation of attacker conflict investment (both responses indicating a lack of effort or understanding since defenders' conflict investment should align with their expectation of attackers' aggression), their responses were excluded. Following these exclusions, our sample comprised 85 attackers and 117 defenders (89 female; age M = 39.22, SD = 13.93, range 19–72 years).

Experimental Procedures. Participants were randomly assigned to either the attacker or the defender condition. After providing informed consent, they received extensive instructions on the TAD-C. Participants learned that they would be paired with another participant in the opposing role after the completion of the experiment and that their pay-off would be calculated based on both their own and the other participant's decisions. All instructions used neutral language to avoid framing effects.

Participants responded to comprehension questions to make sure that they understood the rules of the TAD-C and then made decisions for all items of the strategy method in their condition. In both the attacker and defender condition, participants made decisions for various scenarios, manipulating the chances of being able to transfer MUs to the attacker (e.g., “In this scenario, Participant B’s information is that there is a 60% chance that you *cannot* transfer anything and 40% chance that you can choose to transfer MU. You can make a transfer, but Participant B does not know this with certainty.”; Ranging from 0%, 20%, …, to 100%). These *chance to transfer*-levels resulted in a 6-item within-participant manipulation for defenders. In the attacker condition, participants made choices conditional on both the *chance to transfer* and 7 levels of transfer, resulting in 36 items. As the *chance to transfer*-manipulation only had small effects on conflict investment and did not affect other results in a meaningful way, we ignore this manipulation henceforth and examine results across levels.

Within each scenario, defenders indicated (i) “how many MU do you transfer to Participant B?” (i.e., transfer pay: 0 MU, 5 MU, …, to 30 MU), (ii) “how many MU do you assign to the Challenge Pool (i.e., defense investment; 0 MU to 30 MU), and (iii) “how many MU do you think Participant B will assign to the Challenge Pool (expected attacker investment; 0 MU to 30 MU). Attackers were asked to indicate, for 7 possible level of transfer from their defender (i.e., 0 MU, 5 MU, …, to 30 MU) (i) “how many MU do you assign to the Challenge Pool (i.e., attack investment; 0 MU to 30 MU) and (ii) “how many MU do you think Participant B will assign to the Challenge Pool? (i.e., expected defender investment; 0 MU to 30 MU).

Following the investment decisions, participants filled out the social value orientation (SVO) slider measure (Murphy, Ackermann, & Handgraaf, 2011) by making six decisions involving the selfish versus prosocial allocation of money between themselves and another person. Decisions were scored as more prosocial if more money was sacrificed in favor of the other person. For example, in one decision problem, the participant could choose between allocating 100 points to themselves and 50 points to the other person (i.e., the maximal proself option) or 50 points to themselves and 100 points to the other person (i.e., the maximal prosocial option). From participants' responses, an SVO angle can be calculated, with a higher score indicating greater baseline prosociality. After completing the SVO slider measure, participants were debriefed.

Participants were paid via the prolific.co platform. They received a 3.20 GBP participation fee and an additional performance-based payment. For the TAD-C, performance-based payments were calculated based on participants' investment decisions and investment expectations. We selected one decision of each defender and paired it with a decision by a randomly chosen attacker. Since the sample included more defenders than attackers, some attackers were matched with more than one defender. In this case, the attacker's pay-off was calculated based on the defender that they were matched with first. Payoffs were converted into GBP at a rate of 1 MU = 0.20 GBP**.** For the investment decision, we calculated payoffs according to the rules of the TAD-C. Expectation responses were also incentivized, with participants earning 1 GBP if they correctly estimated how much the other participant would invest in the challenge pool. For the SVO slider measure, participants' performance-based payoff was calculated based on participants' own allocation on one randomly-selected decision and on what participants received from one randomly chosen other participant.

Results

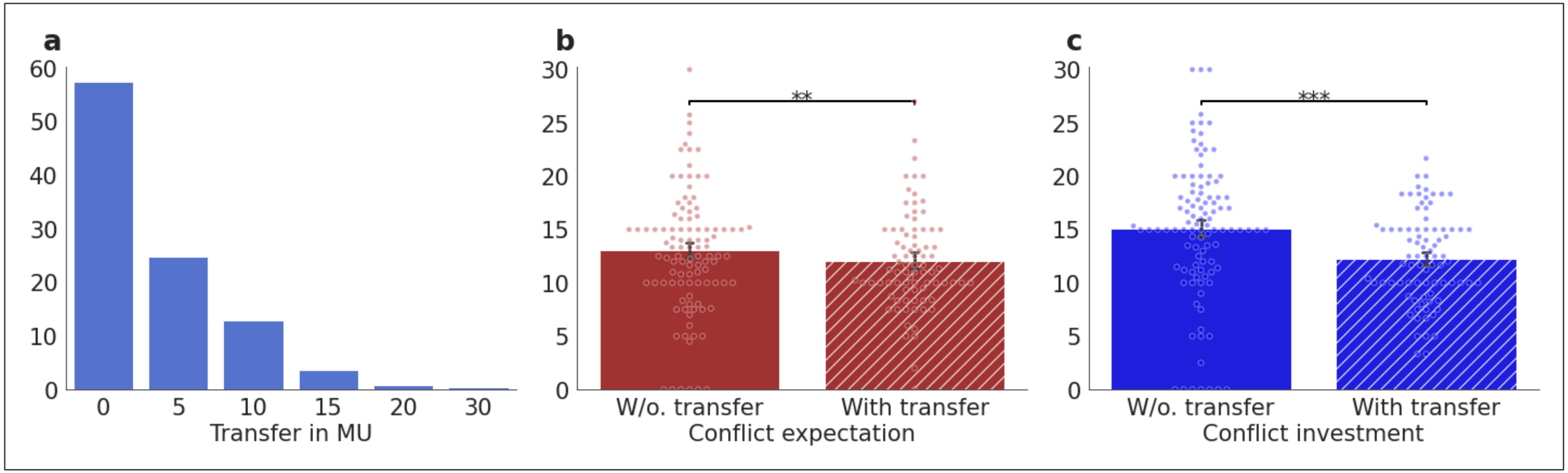
Analysis Strategy. Similar to study 1, we used random intercept models for our analysis to account for possible violation of independence in our data. However, unlike study 1, there was no dyad level in study 2, so we utilized a two-level model with individual decisions nested within participants. For our analysis, we used the same software packages as in study 1.

Defender Beliefs and Behavior. Confirming our first hypothesis, defenders gave more than zero in 42.56% of all decisions. The majority of non-zero transfer decisions clustered at 5 MU (24.79%), 10 MU (12.99%), and 15 MU (3.58%; Figure 4a). Defenders transferred on average 3.35 MU (intercept = 3.35, $p > .001$; Table 4) with an average transfer "magnitude" (i.e., excluding transfers of 0) of 7.59 MU (intercept = 7.59, $p > .001$; Table 4).

To investigate how defenders' transfer decisions influenced their expectations of attacker aggression and their own conflict investment, we collapsed the data points for levels of transfer larger than zero and compared zero versus non-zero investment decisions. This was done due to the highly skewed distribution of transfer decisions larger than 0 (as described above; Figure 4a). As expected, defenders who transferred (some) MU to the attacker expected the attackers to invest less in aggression (*transfer* coefficient = -1.09, $p = .021$; Table 5, Figure 4b). Hence, defenders believed that making transfers would appease their attacker, and this, indeed, significantly reduced defense investment (*transfer* coefficient = -2.77, $p < .001$; Table 5; Figure 4c), again replicating the findings from study 1.

Figure 4

Defenders' (a) decisions for transfer by amount of MU (in percentage), and their (b) conflict expectation of attackers (in MU) and (c) conflict investment for decisions without (solid) vs with (dashed) transfer in the TAD-C strategy method.



Note. Shown are mean values (bars) and standard errors (± 1 SE). Contrasts are significant at *p < .05, **p < .01, and ***p < .001.

Table 4

Results of linear random intercept mixed models for defenders in the TAD-C strategy method predicting defender transfer and defender transfer magnitude (study 2). The intercept estimates the mean difference of these variables from 0.

Dependent Variable	Predictor	Estimate (*b*)	Test statistic (*t*)	*p*
Defender transfer	(Intercept)	3.35	10.26	< .001
Defender transfer magnitude	(Intercept)	7.59	22.86	< .001

Note. Estimates for aggregated effects using linear mixed models with random effect *participant*.

Table 5

Results of linear random intercept mixed models showing how defenders' decision to transfer (without vs with) impacts various outcome variables for defenders in the TAD-C strategy method (study 2).

Dependent Variable	Predictor	Estimate (*b*)	Test statistic (*t*)	*p*
Defender conflict investment	(Intercept)	15.06	28.12	< .001
	Transfer: With	-2.77	-6.48	< .001
Defender conflict expectation (of attacker)	(Intercept)	13.12	25.14	< .001
	Transfer: With	-1.09	-2.31	.021

Note. Estimates for aggregated effects using linear mixed models with random effect *participant*.

Attacker Beliefs and Behavior. In accordance with hypothesis H2, our regression model revealed a strong decrease in attackers' aggression with increasing levels of transfer by the defender (*transfer* coefficient = -0.29, $p < .001$; Table 6). Further inspection of the relationship between attacker conflict investment and the level of transfer, however, revealed a slight increase in aggression if attackers received 5 MU (from 10.59 MU at 0 to 11.78 MU) and 10 MU (to 11.26 MU) from the defenders. This indicates that attackers partially used their additional resources to aggress and "exploit" the defenders at these lower levels of transfer. This is followed by a steep decrease in conflict investment starting at a transfer level of 15 MU, suggesting that attackers adjust their conflict spending to the decreasing amount of MU that defenders have available for defense.

Classification according to social value orientation showed that our sample consisted of 38 proself and 47 prosocial attackers. A visual inspection (see Figure 5a) of attacker aggression by defender transfer separated by a prosocial versus proself social value orientation showed that prosocial attackers aggressed against defenders less than proself attackers across all levels of transfer. This difference was particularly pronounced for lower levels of transfer (5 MU, 10 MU and 15 MU). To assess these differences statistically, we fitted a random intercept model predicting attacker conflict investment from SVO angle (allowing for a more nuanced analysis of individual differences than SVO type), level of transfer, and their interaction (see Table 6). Indeed, in line with hypothesis H2a, our model revealed a negative effect of SVO angle on aggression (*SVO angle* coefficient = -0.09, p = .030), indicating that that attackers with a more pro-social value orientation were more likely to lower their conflict investment when receiving a transfer. We also found an interaction between SVO angle and defenders' transfer (*SVO angle* × *transfer* coefficient = 0.002, p = .001), confirming that this moderating effect of prosociality on attacker aggression was more pronounced at lower levels of transfer.

Figure 5

Attackers' (a) conflict investment (in MU) by level of defender transfer, and b) decisions to invest 0 MU into conflict by level of defender transfer, both delineated by prosocial (dashed) vs proself (solid) SVO (collapsed for all chance to transfer-levels)

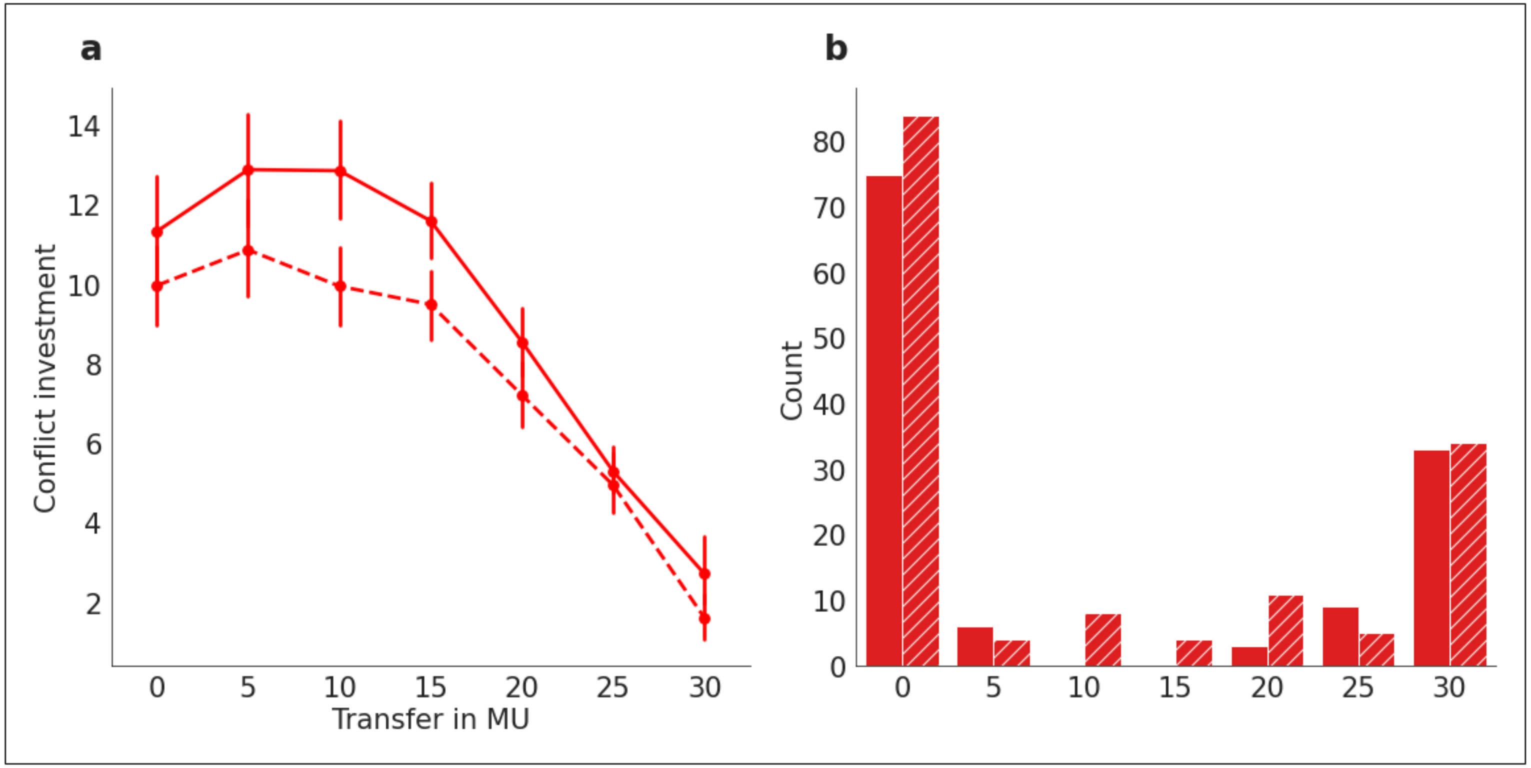


Table 6

Results of linear random intercept mixed models showing how defender transfer (baseline: 0 MU) and SVO angle (baseline: 0°) impacts attacker conflict investment in the TAD-C strategy method (study 2).

		Model incl. main effects			Model w. added interaction effect		
Dependent Variable	Predictor	Estimate (*b*)	Test statistic (*t*)	*p*	Estimate (*b*)	Test statistic (*t*)	*p*
Attacker conflict investment	(Intercept)	14.32	11.90	< .001	15.07	12.30	< .001
	Transfer	-0.29	-30.50	< .001	-0.34	-18.49	< .001
	SVO angle	-0.07	-1.53	.131	-0.09	-2.20	.030
	SVO angle x Transfer				0.002	3.21	.001

Note. Estimates for aggregated effects of *Transfer* (baseline: 0 MU) and *SVO angle* (baseline: 0°) on various outcome variables using linear mixed model with random effects *participant*.

Conclusions and Discussion

In this study, we investigated if and how appeasement in the form of resource transfers could mitigate conflict between an aggressing and defending party. Two experiments demonstrated that defenders indeed transfer a part of their resources to a potential aggressor, confirming our first hypothesis. Moreover, defenders expected the attackers to become less aggressive in response to the transfer, leading them to reduce their own conflict investment. Findings thus provide evidence that resource transfers are employed as a conflict resolution strategy, with defenders expecting to appease the attackers and deescalate the conflict. Our second hypothesis was also supported, but with some complexity. The comparison of the normal Attacker-Defender Contest and its extended version showed that appeasement was indeed successful in reducing aggression and overall conflict. However, it was not universally effective. Closer analysis of the Transfer Attacker-Defender Contest revealed that while defenders reduced their defense spending after transfers, responses from attackers varied: some reduced their conflict investments ("appeased" attackers), while others used transfers to escalate aggression ("exploitative" attackers). Our second experiment therefore used a strategy method to further explore attackers' motives. While attackers generally reduced their conflict investment in response to defender transfers, they also displayed a modest "exploitative" pattern, strategically adjusting their conflict spending based on transfer levels and the defenders' remaining resources. Supporting our hypothesis, we found that prosocial attackers were more likely to respond to transfers with reduced conflict investment, while selfish attackers were more likely to escalate conflict.

Overall, our findings therefore offer a nuanced understanding of appeasement strategies in conflict situations. While defenders made use of the opportunity to transfer resources, leading to an overall decline in attackers' aggression and conflict, we also found that attackers' responses varied, encompassing both appeasement and exploitation. Crucially, these differing responses were shaped, at least in part, by attackers' social value orientation.

Implications

Our research contributes to the understanding of conflict resolution strategies, specifically to the possibility of using appeasement to prevent potential aggression. Findings connect to earlier work on bargaining strategies and reciprocal tension reduction (Boyle and Lawler, 1991; Large, 1999, Lawler et al., 1999, Osgood, 1962) and research showing the effectiveness of unilateral concessions in building trust and reducing punitive actions (Lindskold and Han, 1988; De Dreu, 1995). Our findings extend and partly support this research by demonstrating that appeasement, in the form of resource transfers, can reduce the aggressors' conflict investments, and overall conflict.

However, our study also introduces a more nuanced perspective on previous theory. Indeed, many attackers "accepted" resource transfers as appeasement and responded by reducing their aggression. This finding resonates with previous work on reciprocity, suggesting that some attackers felt compelled to "return the favor" by not attacking the defender (Cialdini, 1984; Cialdini & Goldstein, 2004; Gouldner, 1960; Regan, 1971). Similar behavior has, for example, been observed in trust games where trustees often abide by some implicit norm of reciprocity and back transfer a non-trivial amount to the trustor (Berg et al., 1995; Chaudhuri and Gangadharan, 2007; Cox, 2004). We also found, however, that appeasement was not universal: Some attackers behaved more in line with predictions made by standard economic theory and exploited the situation by using transferred resources for aggression. As demonstrated in experiment 2, these differences were, at least in part, contingent on individuals' (pro-)selfish orientation. In this regard, our findings echo past experimental work which demonstrates how social value orientation predicts collaborative outcomes in scenarios of conflict and cooperation (see e.g., De Dreu et al, 2019; Thielmann et al., 2020; Van Lange et al., 2013), and highlight the critical role that individual differences play in these situations.

Contrary to the predictions of standard economic theory, we observed that defenders' made use of the option to appease attackers through resources transfers. Importantly, defenders' decision to transfer resources was linked to their expectation that attackers would reduce conflict investment, and to lowering their own defense spending. This finding is consistent with previous work on trust games, showing that the trustor's decision to transfer resources is influenced by beliefs about the receiver's trustworthiness (Berg et al., 1995; Chaudhuri and Gangadharan, 2007; Cox, 2004), and research on public good games showing that cooperation is contingent on beliefs about other players' willingness to cooperate (Fehr & Gächter, 2000). Consequently, our results underscore the critical role of beliefs and expectation in shaping cooperative decision making in conflictual situations.

Findings may offer some insight for policymakers and negotiators that seek to deescalate real-world conflicts. Our research suggests that strategic appeasement might be a viable strategy for mitigating aggression and preventing conflict. Crucially, however, the choice of appeasement as a strategy should be contingent upon a deep understanding of the opposing party's values and characteristics. In situations where a potential aggressor may be predisposed towards cooperation and overall beneficial outcomes, resource transfers might de-escalate and foster stability. This approach has historical precedent, such as in the Chinese tributary system, where it effectively maintained peace for long periods. However, using strategies of appeasement towards an unabashedly self-serving aggressor may backfire, as in the case of the Munich Agreement of 1938 which further enabled Hitler's aggressive expansion.

Limitations and Future Research

Although our work was partly inspired by historical precedent, we tested our predictions in stylized experimental contests between two individuals. The strength of this approach lies in its internal validity and enables us to draw causal inference about the effects of transfer opportunities in conflicts between an attacking and defending party. While providing valuable insights, this approach might not fully capture the complexities of real-world situations. Factors to think about when generalizing our findings to other contexts include the involvement of multiple parties, group dynamics, conflicts extending beyond the basic roles of attacker and defender, asymmetries in resources and power, and the impact of long-standing, nuanced histories between conflicting parties. Some of these complexities might be addressed through simple experimental extensions. For example, future studies could look at third-party interventionism (cf. Fehr & Fischbacher, 2004; Lotz et al., 2011) or extend our design to a group-based contest (cf. Bornstein, 2003; De Dreu et al., 2016). In addition, future research could further expand our understanding of conflict and appeasement by integrating experimental work with macro-level data (cf. De Dreu et al., 2016; De Dreu et al., 2022).

Our study points to the importance of individual differences, in particular social value orientation, in moderating the response of aggressors towards appeasement. While pro-sociality moderated attackers' aggression, this effect was limited in scope. Even pro-social attackers still used some or their resources to aggress on defenders. Future research could therefore further investigate the role of individual differences by examining other psychological factors that might influence aggression and the response to appeasement. For instance, future research might investigate how traits such as risk aversion, empathy, guilt sensitivity, or dominance orientation affect how individuals behave in this context. Such work could deepen our understanding of the individual characteristics that shape behavior in conflicts and thus improve our ability to manage and de-escalate real-world conflicts.

Conclusion

Overall, our research provides a nuanced perspective on the dynamics of conflict and appeasement through resource transfers. We found that resource transfers can indeed function as a strategy of appeasement, leading to a decrease in aggression and overall conflict. However, the effectiveness of this approach was not universal, with individual social preferences playing an important role in determining the response to appeasement. Findings do not only contribute to our theoretical understanding of conflict resolution, but also carry implications for real-world conflict management and negotiation practice. Future research might address additional situational complexities and individual differences in order to archive a more comprehensive understanding of human conflict and its mitigation through appeasement.

Chapter 3 - Costly Peace and Wasteful Conflict: Theory and Experimental Evidence

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Abstract

Agents can gain wealth through economic production and through predatory capture of wealth produced by others. Whether and how these two mechanisms relate to each other remains largely unresolved. Here we provide formal theory and experimental tests integrating earlier work on wealth production and protection with recent theory on attacker-defender contests. In principle, having opportunities for economic production should reduce conflict investments. When 'production thresholds' are low, facilitating easy wealth acquisition, agents should invest less in predatory attacks and protective defense. An experiment comparing attacker-defender contests with or without a production option confirms that the latter reduces investment in conflict yet does not eradicate it; agents continue to invest in attacks, forcing counterparts to invest in defense rather than production. When production is comparatively difficult, predatory attacks persist and post-conflict wealth inequality between attackers and defenders is amplified.

Keywords: conflict, attacker-defender contest, production, inequality

Introduction

To advance social and economic prosperity, humans invest in the production of goods and services or in the appropriation of goods and services provided by others (Pareto, 2014; Haavelmo, 1954). Investing in production can provide agents with economic wealth and lead to collectively beneficial trade. In contrast, investing in the appropriation of goods and services produced by others can create costly conflict between those who seek to appropriate and those who seek to defend and protect what they have produced (De Dreu & Gross, 2018; Duffy & Kim, 2005; Usher, 1987). Compared with wealth creation through economic production, wealth creation through predatory capture and conflict is collectively inefficient (Besley & Mueller, 2018; De Dreu & Gross, 2018; McGuirk & Burke, 2020; Smith et al., 2012). A key question for economic theory and conflict resolution is thus when and why humans invest in economic production rather than investing “effort on injuring others, and protecting against being injured” (Mill, 1978).

Scholars in political economy and conflict studies have argued that opportunities for wealth creation through economic production lower the incentives for engaging in conflict (Maoz & Russett, 1993; Jablonski & Oliver, 2013; Rousseau et al., 1996; Wittman, 2000). Political commentator Thomas Friedman argued, for example, that “[no] two countries … fight a war against each other as long as they are both part of the same global supply chain” (Friedman, 2006, p. 421). Shortly after World War I, John Maynard Keynes conjectured in a similar vein that excessive war compensation payments demanded from Germany will harm its national economy and might push the country to seek prosperity through (renewed) attack: “If we aim deliberately at the impoverishment of Central Europe, vengeance, I dare predict, will not limp” (Keynes, 2019, p. 192). Yet, the idea that creating opportunities to generate wealth through production reduces predatory capture and conflict (both within and between nation-states) is not without its critics (Luce, 2015) and both theoretical and empirical findings are mixed. In fact, the assumption that economic production opportunities decrease conflict is not always supported. Furthermore, there is also reason to assume that creating such opportunities increases rather than decreases the probability and intensity of conflict (cf. the "natural resource curse"; Brunnschweiler & Bulte, 2009; Lujala et al., 2005; van der Ploeg, 2011).

Here we ask not whether, but rather *when* opportunities for wealth creation through economic production reduce or increase the "effort spent on injuring others and protecting against being injured." To this end, we develop a formal model on production and predation and test its predictions in a behavioral experiment. In doing so we integrate economic theory on wealth creation with recent advances in the study of asymmetric conflicts. This allows us to gain a better understanding of when and why individuals initiate and escalate conflict, or, alternatively, move towards peaceful co-existence.

Predation, Defense and Production

The starting point in our analysis is that conflict emerges when the interests and values of interdependent (groups of) individuals are incompatible (Coombs, 1987; De Dreu, 2010; Schelling, 1981). Incompatible interests can revolve around the distribution of power and resources, opposing standpoints on economic policy and the governance of public goods, or social policy concerning social/religious values, including, for example, justice, minority rights, and freedom of speech (De Dreu, 2010; Raiffa, 1985; Rapoport et al., 1965). Crucially, whereas incompatibilities can concern something both parties want and only one can have, most concern something that one party wants that another party owns and maintains. Examples of such asymmetric conflicts between an 'attacker' and 'defender' include international disputes between revisionist and non-revisionist states (Wright, 2014), piracy (Jablonski & Oliver, 2013), terrorist attacks (Burgoon, 2006), hostile take-over attempts in industry (Schwert, 2000), and politicians contesting (versus defending) the socio-economic status quo (De Dreu et al., 2021). In all these and similar cases, one party seeks to advance its own interests – exclusionary access to scarce resources, market share and production capacities, or political influence – at the expense of those of another party who, in turn, invests in protecting its interests against predatory capture (Carter & Anderton, 2001; Cornes & Hartley, 2005; Dechenaux et al., 2015; De Dreu & Gross 2019; Grossman & Kim, 1996a, 1996b; Hirshleifer, 1988; Tullock, 1980; McGuirk & Burke, 2020; Pruitt et al., 2004; Shane & Magnuson, 2016).

Recent work has teased apart these two reasons for conflict investments—predatory attack and protective defense—in asymmetric “attacker-defender” contests in which one agent, as an “attacker”, invests to capture resources from the other, who, as a “defender,” invests to protect against such predatory attack (Chowdhury & Topolyan, 2016; Clark & Konrad, 2007; De Dreu & Gross, 2018; Hausken & Zhuang, 2011; Powell, 2007). Experiments implementing both one-shot and repeated interaction versions of such attacker-defender contests have shown that humans invest in attack and defense, and that these investments frequently deviate from rational-choice equilibrium play (Chowdhury et al., 2018; Chowdhury & Topolyan, 2016; De Dreu et al., 2021). Such deviations have been attributed to, for example, overconfidence (Johnson & Fowler, 2011; Tversky & Kahneman, 1992), anti-social preferences and competitive arousal (De Dreu et al., 2019), and incorrect beliefs about the counterpart’s aggressiveness (Jervis, 1978; Rojek-Giffin et al., 2020).

The attacker-defender contest provides a tool to identify not only why individual contestants over-invest, but also when and why conflict emerges in the first place. We can begin by asking what motivates attackers to avoid conflict and instead seek economic prosperity through other, more peaceful means. As already noted at the outset, providing agents with alternative opportunities to produce wealth may reduce the temptation to invest in predation and—for the targets of predation—the need to invest in defense (Maoz & Russett

1993; Rousseau et al., 1996; Williams, 2019; Wittman, 2000). Evidence for this would resonate with Keynes' intuition about the detrimental effects of war compensation payments and fit with the evidence that providing criminal offenders with job opportunities reduces their likelihood to commit burglary (Becker, 1968; Uggen & Shannon, 2014), and that firms with more innovative research and development activities are more likely to engage in friendly rather than hostile takeovers (Bena & Li, 2014).

The possibility that adding opportunities for production reduces conflict comes, however, with the heretofore ignored caveat that agents with strong production capacities and concomitant wealth appear as attractive targets for exploitation. When both attacker and defender are given opportunities for production, defenders may become wealthier, increasing the potential spoils of war for would-be attackers (Durham et al.,1998; Hirshleifer, 1991; Skaperdas, 1992; Lacomba et al. 2014). Similarly, studies on the "natural resource curse" have shown that countries richer in natural resources are more often involved in ethnic clashes (Lujala et al, 2005) and international conflicts (van der Ploeg, 2011), are more likely to be the target of aggression (Koubi et al., 2014), and tend to invest more in territorial defense (Ali & Abdellatif, 2015; Khan et al., 2022). In short, when both sides can produce wealth through economic production, attackers need to strike a balance between the attractiveness of substantial spoils of war from predation, and the risk of wasting resources on unsuccessful attacks (also see Carter & Anderton, 2001; Grossman & Kim, 1996b, 1996a). Conversely, defenders need to strike a balance between investing in economic production and the risk of mounting too weak a defense to prevent predation. Accordingly, opportunities to create wealth through economic production could, somewhat paradoxically, increase rather than decrease investment in predatory attacks and protective defense, depending on the costs and benefits of production.

Modeling Predation and Production

To identify whether adding production opportunities decreases or increases investment in predatory attack and protective defense, we contrast contests in which agents lack a production opportunity, i.e., 'pure' contest environments, with environments in which such an opportunity is available. Giving agents the discretionary freedom to invest in conflict and, when available, production, allows us to see whether and how adding opportunities for production decreases or increases investment in predation, in defense, or both. In addition, we can track the emergence of post-conflict wealth inequality between attackers and defenders, a common outcome of such asymmetric contests (De Dreu & Gross, 2019).

The Attacker-Defender Contest. The starting point in our model is a simple attacker-defender contest (De Dreu & Gross, 2019; henceforth, AD-C). Both attacker and defender enter the interaction with an endowment *e*, and decide how much of their endowment to invest in attack (for the attacker, *a*) or in defending against such an attack (for the defender, *d*). Conflict investments are lost, but if the attacker's investment exceeds that of the defender ($a > d$), the attacker appropriates the defender's remaining endowment and adds it to their own. In contrast, if *d* is equal to or larger than *a*, both keep their remaining endowments. The attacker's payoff is therefore:

$$\pi_{Att}(a,d) = \begin{cases} e - a & if\ a \leq d \\ 2e - a - d & if\ a > d \end{cases}$$

while the defender's payoff is:

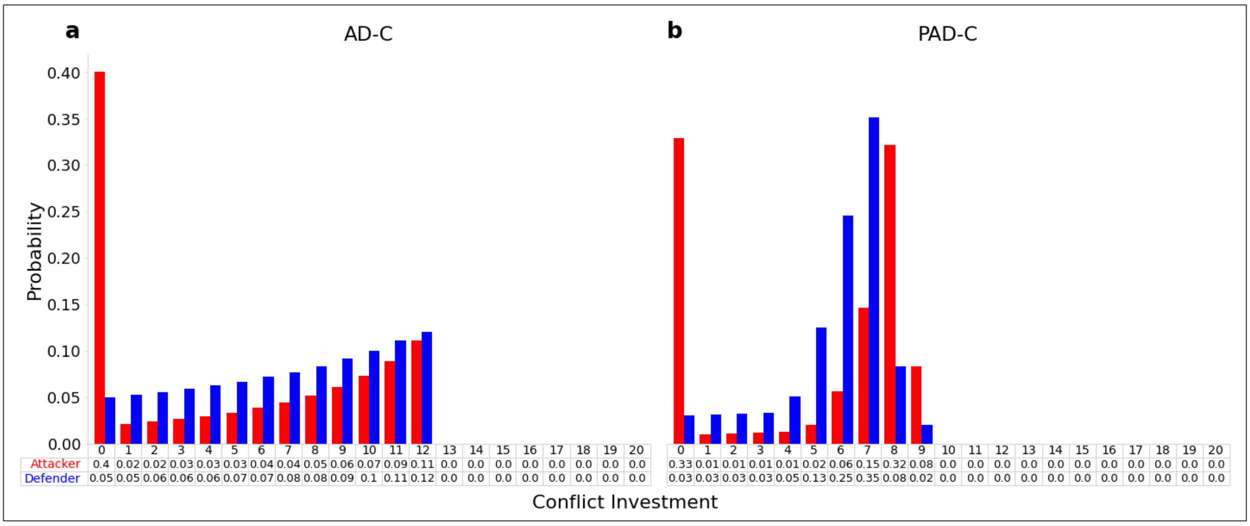
$$\pi_{Def}(a,d) = \begin{cases} e - d & if\ a \leq d \\ 0 & if\ a > d \end{cases}$$

Players in the AD-C have no dominant strategies: the level of attack that maximizes the attacker's payoff depends on the investment made by the defender. Likewise, for the defender, the level of optimal defense depends on what the attacker invests. As shown elsewhere (Méder et al., 2022), the AD-C has a single Nash equilibrium in mixed strategies.

In equilibrium, rational players randomize between devoting 0, 1, 2… resources to the contest, up to a certain highest investment, around 1 - 1/e ≈ 63% of the original endowment. The attacker's strategy is bimodal, assigning a relatively high probability (close to 1/e ≈ 37%) to entirely refraining from attacking, but making a 'weak' attack unlikely. The defender's equilibrium strategy also assigns higher probabilities to stronger rather than weaker defensive actions, but—in contrast to the attacker's equilibrium mix—not defending at all is the least likely action (an example with $e_{A,D}$ = 20 is shown in Figure 1a). Because investments are non-recoverable, neither attacker nor defender should invest anything in conflict from a collective welfare perspective. Nonetheless, if agents play equilibrium strategies, they will collectively spend about 12 MU of their initial endowments on conflict (see Table 1).

Figure 1

Nash equilibrium strategies in AD-C and PAD-C



Note. Probabilities with which each conflict investment strategy from 0 to 20 (x-axis) should be chosen for attacker (red) and defender (blue), assuming rational selfish play and risk neutrality, under equilibrium. (a) Predictions for the Attacker-Defender Contest (AD-C) as implemented in the experiment. (b) Predictions for the Production Attacker-Defender Contest (PAD-C) as implemented in the experiment.

Table 1

Average play for key variables calculated with the probability weights of the equilibrium distribution for attacker and defender for the experimental version of AD-C and PAD-C (i.e., with endowment e = 20).

	Attacker-Defender Contest (AD-C)		Production Attacker-Defender Contest (PAD-C)	
	Attacker	Defender	Attacker	Defender
Conflict Investment	4.961	7.039	4.896	5.79
Conflict magnitude	4.961	7.039	4.896	5.791
Conflict frequency	0.600	0.950	0.672	0.970
Production investment	–	–	8.951	12.684
Earnings	20.000	8.000	33.484	11.000

The Production Attacker-Defender Contest. We contrast the AD-C with a production attacker-defender contest (henceforth, PAD-C) where agents may also invest all or part of their endowment in production, denoted by b_{Att} and b_{Def}. To be successful at production, an individual's production investment must meet or exceed a certain fixed threshold T (with $0 \leq T \leq e$). If they reach or exceed threshold T, each player receives a fixed reward k. Production investments are non-recoverable and made simultaneously with the conflict investments (a and d). The total amount invested in production and attack (or defense) is thus constrained by e such that $a + b_{\text{Att}} \leq e$ and $d + b_{\text{Def}} \leq e$. Henceforth we assume that agents know the threshold at the start of the game.

Like the AD-C, the PAD-C has a single mixed-strategy equilibrium (Figure 1; for formal analysis see Méder et al., 2022). However, adding production opportunities with threshold *T* changes the equilibrium prediction for investments into attack and defense for two reasons. First, defender payoffs are conditioned by the production return *l(b)*:

$$\pi_{Def}(a, d, b_{Def}) = \begin{cases} 0 & if\ a \leq d \\ e + l(b_{Def}) - d - b_{Def} & if\ a > d \end{cases}$$

Therefore, the attacker's spoils of conflict in case of victory are conditioned by the defender's production return, as well as the attacker's own production return:

$$\pi_{Att}(a, b_{Att}, d, b_{Def}) = \begin{cases} e + l(b_{Att}) - a - b_{Att} & if\ a \leq d \\ 2e + l(b_{Att}) + l(b_{Def}) - a - d - b_{Att} - b_{Def} & if\ a > d \end{cases}$$

For both attacker and defender, the production return *l(b)* depends on meeting or exceeding the production threshold T:

$$l(b) = \begin{cases} k & if\ b > T \\ 0 & if\ b \leq T \end{cases}$$

Our model makes two assumptions regarding the relationship between the parameters. First, production is only feasible if the initial endowment can cover it, that is, with $e \geq T$. Second, whenever $k \leq T$, and investments in production give a negative return, the production technology is deemed inefficient and not used. Since this reduces the PAD-C game to the AD-C, we also assume $k > T$. Accordingly, we can represent the PAD-C game by modifying the payoff matrix of the AD-C in the following way: whenever each side invests not more than $e - T$ in conflict, their respective payoff is increased by $k - T$, and is otherwise unchanged. In addition, whenever the attacker wins the conflict, this payoff increase is transferred from the defender to the attacker (see Table 2).

Table 2

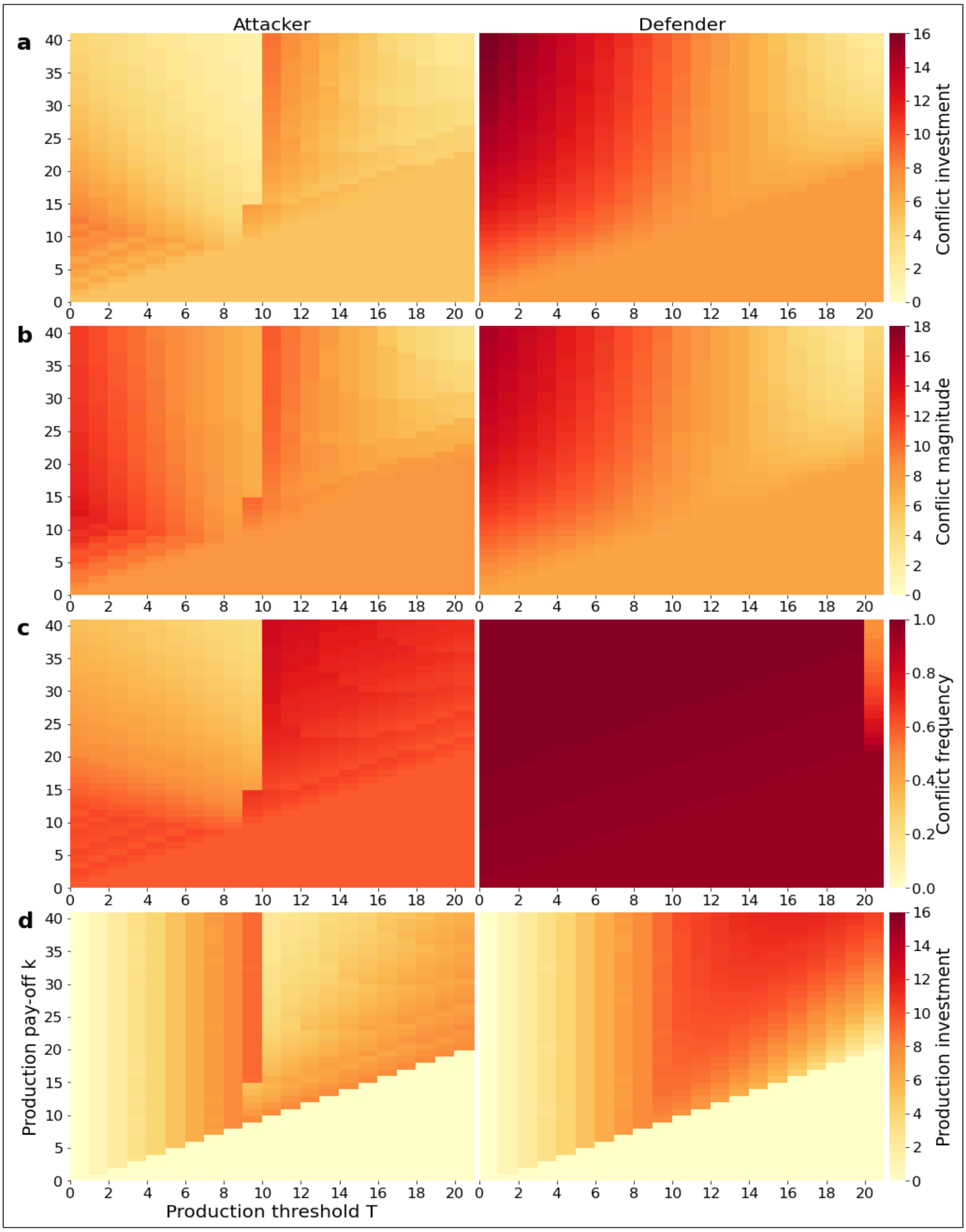
Pay-off matrix for the AD-C (top) and PAD-C (bottom) as a function of attacker (columns) and defender (rows) investment in conflict, with endowment e = 4 and, in the PAD-C, production reward k = 5, production threshold T = 3. Within each cell, the attacker (defender) earns the right (left) payoff. Bold digits (bottom panel) indicate payoff changes compared to the AD-C game (top panel).

Attack\Defense	0	1	2	3	4
0	4,4	4,3	4,2	4,1	4,0
1	7,0	3,3	3,2	3,1	3,0
2	6,0	5,0	2,2	2,1	2,0
3	5,0	4,0	3,0	1,1	0,0
4	4,0	3,0	2,0	1,0	0,0
0	**6,6**	**6,5**	**6**,2	**6**,1	**6**,0
1	**11**,0	**5,5**	**5**,2	**5**,1	**5**,0
2	**8**,0	**7**,0	2,2	2,1	2,0
3	**7**,0	**6**,0	3,0	1,1	0,0
4	**6**,0	**5**,0	2,0	1,0	0,0

To map equilibrium predictions as a function of production threshold *T*, production payoff *k* and $e = 20$ (as used in the experiments reported below), we used the Lemke-Howson algorithm (Lemke & Howson, 1964). Figure 2 shows the mixed-strategy equilibrium in which both attacker and defender assign positive probabilities to using 0, 1, … up to a certain upper bound, which we denote with l^*. Since the support of the equilibrium strategy always includes refraining from attack ($a = 0$), the expected payoff of the attacker is simply $e + k - T$. For the defender, using the upper bound l^* guarantees successful protection and her equilibrium payoff is thus either $e - l^*+k$ or $e - l^*$, depending on whether there are enough resources left over to cover the cost of investing in production.

Figure 2

Heatmaps of average equilibrium play for different variables in the PAD-C



Note. Heat maps showing average values for different variables of interest in equilibrium as a function of production threshold T (x-axis) and production payoff k (y-axis) in the PAD-C. Subplots depict averages for the attacker (left) and defender (right) for (a) conflict investment, (b) conflict investment magnitude, (c) conflict investment frequency and (d) production investment.

As can be seen in Figure 2, the step change in expected payoffs induces changes in equilibrium strategies. When economic production is an 'easy' technology to create wealth (i.e., e - $l^* \geq T$), attackers behave in accordance with Keynes' intuition that providing opportunities for economic production reduces investment in predation (see Figure 2a and 2d for Attacker). Crucially, however, in such settings, defenders *increase* their investment in defense (see Figure 2a and 2b for Defender). This supports the intuition in the natural resource curse literature that increasing wealth through economic production also increases the need to defend against predatory threat. All this changes dramatically, however, when economic production is an 'expensive' technology to create wealth (i.e., e - $l^* < T$). Expensive production constraints defenders from mounting strong defenses, making them attractive targets of predatory acquisition. At the same time, such environments also shift the attackers' focus from production to appropriation, as the latter becomes a relatively attractive technology to create additional wealth (see Figure 2a and 2d for Attacker).

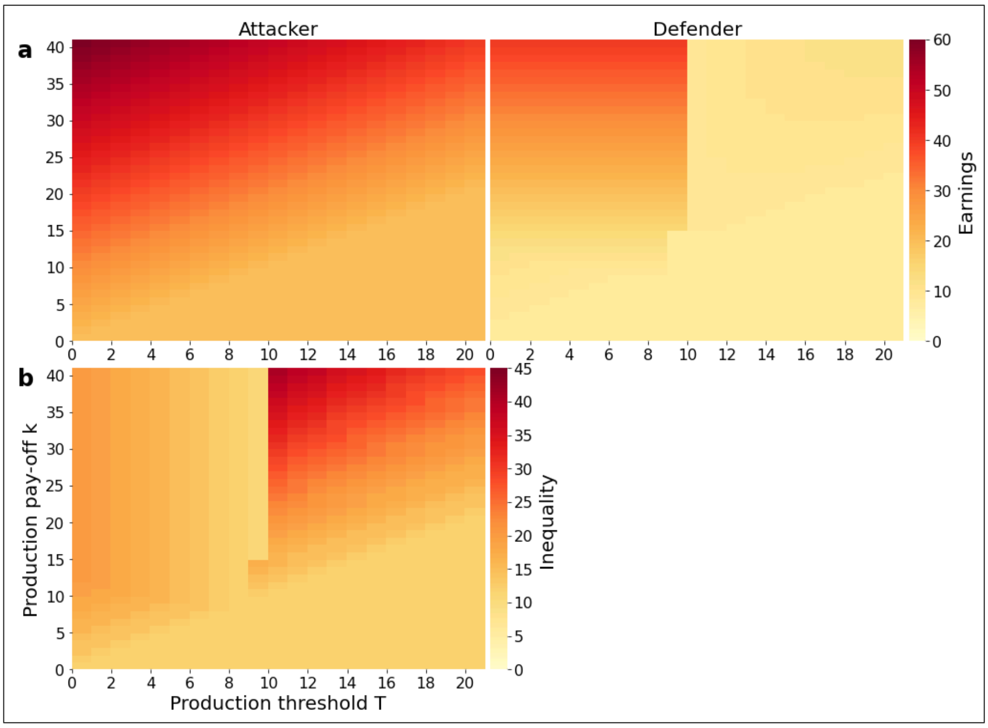
We note that the pattern we observe here for conflict investment also holds for two related but distinct manifestations of 'conflict': conflict magnitude, defined as the average conflict investment when excluding non-conflictual choices (i.e., a = d = 0), and conflict frequency, defined as the proportion of rounds of each party with conflict investments greater than zero, under equilibrium (De Dreu & Gross, 2018; De Dreu et al., 2015). In fact, for both attack magnitude and frequency we observe a stark increase when e - $l^* < T$ (see Figure 2b and 2c for Attacker). In contrast, defense magnitude declines gradually with T, while defense frequency stays consistently high over the range of T and k (see Figure 2b and 2c for Defender). Defense magnitude declines because of the increasing cost of production, while frequency remains steady to maintain protection against potential attack.

In short, adding opportunities for economic production may reduce conflict, but only when production thresholds are low compared to endowments and are therefore easy to meet.

Environments in which production thresholds require higher relative investments embolden predatory capture instead, and result in more frequent and forceful conflicts and a more pronounced inequality in the distribution of wealth. As to the latter, when either l^* or T becomes so large that, when employing the highest level of defense, the defender cannot afford the production investment anymore, we indeed expect a notable collapse in expected defender earnings (see Figure 3a for Defender). Environments with $e - l^* < T$ reinforce conflict and further tilt the balance of earnings towards attackers (Figure 3b). Compared to settings in which individuals have no economic production opportunities whatsoever – the standard AD-C – having expensive production technologies can intensify predatory attack and lead to larger post-conflict inequality in wealth between attackers and defenders.

Figure 3

Heatmaps of average equilibrium play for earnings and inequality in the PAD-C



Note. Heat maps showing average values for different variables of interest in equilibrium as a function of production threshold T (x-axis) and production payoff k (y-axis) in the PAD-C. Subplots depict (a) earnings and (b) expected average inequality where higher values indicate a higher earning difference in the attacker's favor.

Experimental Tests

Our model reveals that opportunities for production can reduce conflict depending on the ease with which production can be realized – the production threshold. We performed experiments to test predictions about (i) conflict investment in attacker-defender contests when production opportunities are absent (AD-C) versus present (PAD-C) and, within the PAD-C, (ii) investment in production in relation to (history of) investment in attack and defense.

In the experiment, we compared the AD-C to the PAD-C as described above. Attackers and defenders were given an endowment $e = 20$ and received a reward $k = 30$ in case of successful production in the PAD-C. We implemented iterative, multi-round contests in both conditions, with attackers and defenders being fixed in dyads for the entire duration of the experiment. In such iterative contests, contestants face uncertainty about their opponent's next move and try to increase uncertainty in their opponent by varying investments across rounds (De Dreu & Gross, 2018; De Dreu et al, 2016). Uncertainty is also a common factor in production environments such as manufacturing (Mula et al., 2006) or agriculture (Ullah et al., 2016), and to mimic this in our experiments we randomly varied threshold T across rounds using a Bernoulli distribution between $T = 9$ (0.45e in Figure 2a and 2b) and $T = 17$ (0.85e) with an expected value of $T = 13$ (0.65e). Accordingly, the production payoff (l) for both attacker and defender in the PAD-C treatments was:

$$l(b) = \begin{cases} 0 & if\ b \leq 8 \\ 30 \ \cdot \mathrm{P}(b \geq T) & if\ 9 \leq b \leq 17 \\ 30 & if\ 18 \leq b \end{cases}$$

where $\mathrm{P}(b \geq T)$ is the probability of the production investment b exceeding the randomly selected threshold T. Note that we specified parameters such that $e - l^* \geq T$ – economic production is comparatively expensive – constraining defenders in their ability to successfully produce and defend simultaneously.

The mixed strategy equilibrium of the analogous PAD-C environment prescribes for attackers (defenders) an average conflict investment of 4.9 (5.8), production investment of 9.0 (12.7), and expected total earnings of 33.5 (11) (see Table 1). Applying backward induction, both the AD-C and PAD-C equilibria can be extended to finitely repeated interactions. Prior empirical work suggests that in repeated interactions, attackers randomize their actions across rounds to make it difficult for defenders to anticipate their best response on a given round. Especially when production thresholds are relatively high (i.e., $e - l^* < T$) and individuals must trade off production and predation to be successful in either, attackers may also alternate across rounds between investing in production and predatory attack. In short, for settings with $e - l^* < T$, our model predicts:

(1a) Production opportunities reduce conflict investment, especially in predatory attack.

(1b) Production opportunities reduce conflict magnitude but increase conflict frequency.

With regards to the role in the conflict, our model predicts:

(2a) Individuals invest in production especially when in the role of attacker.

(2b) Individuals meet the production threshold especially in the role of attacker.

From these predictions, it follows that:

(3) The individual wealth of attackers (defenders) is compromised the least (most) when production opportunities are present (rather than absent).

Method and Materials

Ethics and Participants. The experiments were approved by the Psychology Research Ethics Committee of Leiden University (Protocol #CEP19-0211/75). Participants provided written informed consent and received full debriefing upon conclusion of the study. They were explicitly informed about the study involving fully-incentivized decisions and no deception.

Sample size was determined to be $n = 100$ attacker-defender dyads following a power analysis for a multivariate within-dyad repeated measures (60 contest rounds) design with f = 0.2, α = 0.05 and 1 - β = 0.90. We recruited 124 participants for the AD-C treatment (93 female; age M = 21.15, SD = 2.52, range 18–35 years; five participants did not provide demographic data) and 118 participants for the PAD-C treatment (86 female; age M = 21.80, SD = 3.33, range 17–42 years; 3 participants did not provide demographic data), resulting in 62 and 59 dyads for the AD-C and PAD-C, respectively. Participants received either credits for their participant or a €6.50 show-up fee, as well as the outcome of four randomly selected rounds of decision-making for which earned units were summed and then converted into Euros at a rate of 1 unit = 0.20€ (range €1 to €14.5; M = €7.40).

Experimental Procedures and Treatments.[1] Upon arrival in the laboratory, participants were seated at computers in closed cubicles and then randomly assigned to the roles of attacker and defender. Dyads were randomly allocated to either the AD-C or the PAD-C condition. Participants individually read instructions and answered comprehension questions to make sure they understood the rules of the experiment (for the exact instructions, see De Dreu et al., 2019). All instructions used neutral language to avoid framing effects.

Participants in both treatments made decisions in 60 consecutive contest trials with the same partner. After each trial, participants received full feedback about their own and their counterpart's investments (in conflict and, if applicable, economic production), alongside earnings (from conflict and, if applicable, economic production). We implemented both AD-C and PAD-C as fixed-partner matching protocols and participants were thus able to learn how to compete (and produce) best and to calibrate their strategies over time.

Analytic strategy. Our data set has a hierarchical structure in which each data point (i.e., an investment decision per round) is nested within participants, which are nested within

[1] Participants completed an online questionnaire at least one day before the laboratory experiment. They provided demographic data (gender and age) and filled out some additional surveys which served otherwise unrelated MSc projects. These survey data were not relevant to, and therefore not included in the present analysis.

dyads. To account for possible violations of independence of observations within participants and dyads, we analyzed data with 3-level random intercept regression models with predictors ‘game’ (AD-C/PAD-C), ‘role’ (Attacker/Defender), and the ‘game × role’ interaction:

$\text{OutcomeVar}_{ijk} = \beta_{0jk} + e_{ijk}, e_{ijk} \sim \text{N}(0, \sigma_e^2)$ Level 1 - i = investment

$\beta_{0jk} = \gamma_{00k} + u_{0jk}, u_{0jk} \sim \text{N}(0, \sigma_u^2)$ Level 2 - j = participant

$\gamma_{00k} = 0_{000} + v_{00k}, v_{00k} \sim \text{N}(0, v_u^2)$ Level 3 - k = dyad

Of primary importance were *conflict investment* (hypothesis 1a), *production investment* (hypothesis 2a), and *earnings* (hypothesis 3). For hypothesis 1b, we calculated the *conflict frequency* (the proportion of rounds with conflict investments greater than zero) and *conflict magnitude* (the average amount invested in conflict in rounds with non-zero conflict investment). Additionally, we analyzed attackers’ *conflict victory* rate (the number of attacker victories across all rounds). For hypothesis 2b, we looked at the *production success* rate (the number of rounds in which participants were successful at production). We also investigated the *production magnitude* (the average amount invested in production in rounds with non-zero production investment) and the *return on investment* for production (average overall production earnings per unit spent on production). For hypothesis 3, we calculated the difference between average defender earnings and average attacker earnings.

To explore how participants responded to their opponents’ behavior during the experiment, we created lagged variables for conflict investment and regressed both attackers’ and defenders' conflict and production investments on their opponents' previous-round conflict investments. For all such cross-round “response” models, we used random intercept regression models in which participants were nested within dyads (i.e., with the random effect dyad). Since for the cross-round analysis we were specifically interested in how participants responded to each other’s behavior across rounds, we removed seven dyads in which both attacker and defender had a conflict investment of 0 in all 60 rounds (for all other analyses we used the complete data set). All analyses were performed using the statistical programming language R 3.5.1 (Team, 2016). Linear mixed models were fitted using the lme4 package (Bates et al., 2015) and *p*-values were derived from lme4 extension lmerTest (Kuznetsova et al., 2017).

Results

Investment in Conflict

Hypotheses 1a and 1b addressed conflict investment in attack and defense in the AD-C and PAD-C. In line with hypothesis 1a, we found that adding a production opportunity to the AD-C reduced overall investment in conflict (*game effect*, $p < 0.001$). This reduction did not significantly differ between attackers and defenders (*game* × *role interaction*, $p = 0.896$; Table 3; Figure 4a). Moreover, whereas conflict investments exceeded equilibrium values in the AD-C ($t(61) = 4.32$, $p < .001$ for attackers, and $t(61) = 2.76$, $p = .008$ for defenders), they closely matched equilibrium values in the PAD-C ($t(58) = -1.24$, $p = 0.219$ for attackers, and $t(58) = -1.71$, $p < .093$, for defenders).

In support of hypothesis 1b, we observed a substantial decrease in conflict magnitude between the AD-C and PAD-C (from 54% to 38% of endowment; *game* effect, $p < .001$). For conflict frequency, however, this difference was not significant (*game* effect, $p = .110$; Table 3). This indicates that allowing for production reduced the magnitude of conflict but not its presence. Furthermore, attacker victory-rates were similar in the AD-C (30%) and PAD-C (27%) (*game* effect, $p = .276$; Table 3), meaning that defenders were not less likely to lose their remaining endowments when production opportunities were present.

Table 3

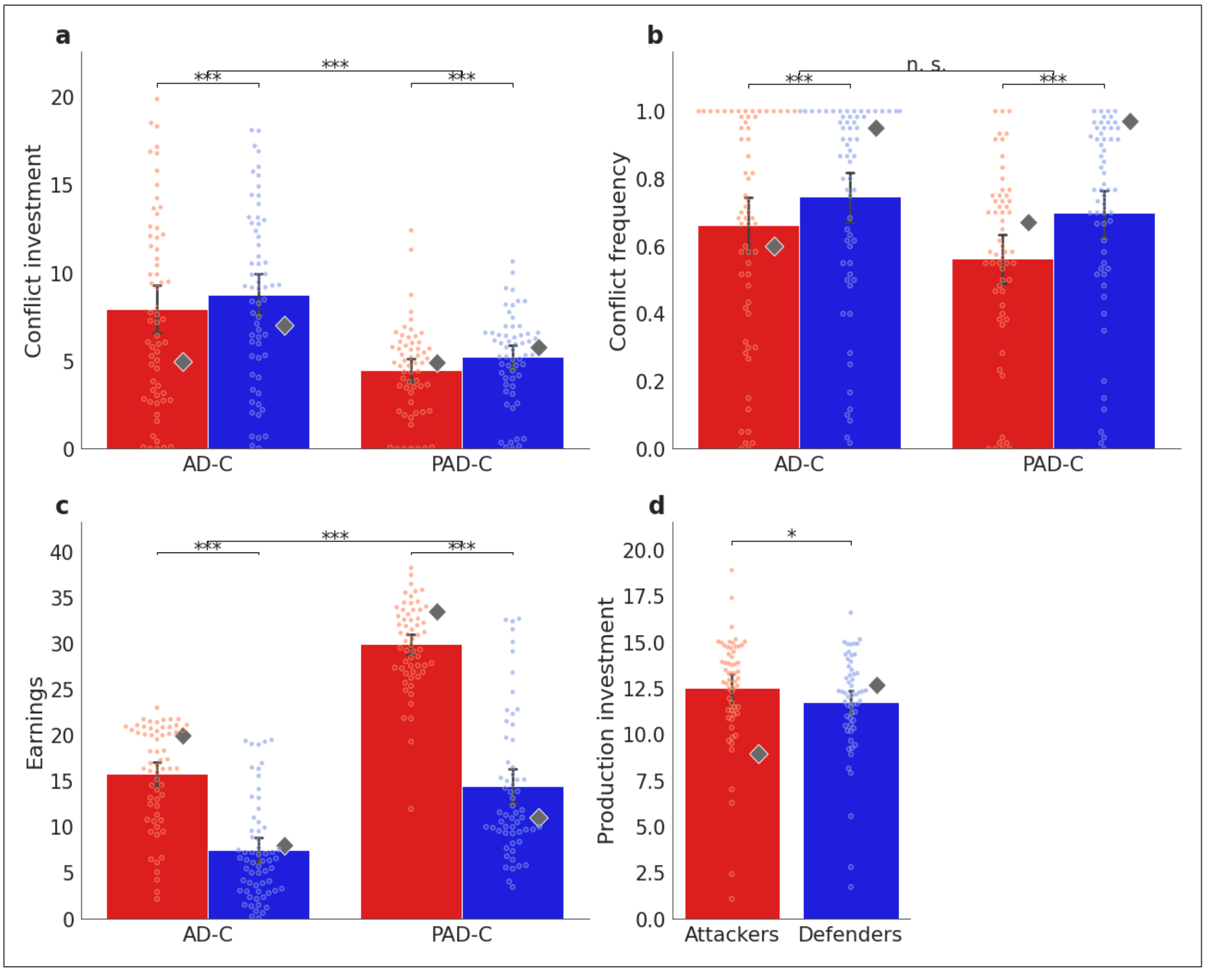
Results of linear random intercept mixed models for conflict investment and outcomes

Dependent Variable	Predictor	Estimate (*b*)	Test statistic (*t*)	*p*
Conflict investment	(Intercept)	7.94	15.17	< .001
	Game	-3.48	-4.64	< .001
	Role	0.82	3.35	.001
	Game×Role	-0.05	-0.13	.896
Conflict magnitude	(Intercept)	10.94	25.09	< .001
	Game	-3.31	5.26	< .001
	Role	0.11	0.43	.666
	Game*Role	-0.20	-0.56	.575
Conflict frequency	(Intercept)	0.69	19.90	< .001
	Game	-0.08	-1.61	.110
	Role	0.08	3.84	< .001
	Game×Role	0.05	1.88	.063
Victory rate (Attacker)	(Intercept)	0.30	15.65	< .001
	Game	-0.03	-1.10	.276

Note. Estimates for aggregated effects of *game: PAD-C* and *role: attacker* on various outcome variables using linear mixed model with random effects *participant* and *dyad.*

Figure 4

Behavioral data and game-theoretic benchmarks for attackers (red) and defenders (blue) in the Attacker-Defender Contest (AD-C) and the Production Attacker-Defender Contest (PAD-C)



Note. Shown are mean values (bars), standard errors (± 1 SE), aggregated investment by subject (dots), and Nash equilibrium predictions (Diamonds). Contrasts are significant at * p < .05, ** p < .01, and *** p < .001.

Production

We hypothesized that individuals in the PAD-C would invest in production, especially when in the role of attackers (hypothesis 2a), and that they would meet the production threshold, especially in the role of attackers (hypothesis 2b). In line with hypothesis 2a, both parties invested in production, but attackers invested more than defenders (*role* effect, $p <$ .018; Table 4; Figure 4d). Moreover, production investments exceeded the equilibrium benchmark for attackers ($t(58) = 9.09$, $p < .001$), but fell below the equilibrium for defenders ($t(58) = -2.58$, $p < .012$) (Figure 4d). While the frequency of investing in production was similar for attackers and defenders (*role* effect, $p = .778$, Table 4), attackers invested in production with greater magnitude (*role* effect, $p < .001$, Table 4).

Table 4

Results of linear random intercept mixed models for production variables

Dependent Variable	Predictor	Estimate (b)	Test statistic (t)	p
Production investment	(Intercept)	12.54	3.42	< .001
	Role	-0.78	-2.44	.018
Production magnitude	(Intercept)	14.32	71.61	< .001
	Role	-0.71	-3.78	< .001
Production frequency	(Intercept)	0.87	37.02	< .001
	Role	-0.01	-0.28	.778
Production success rate	(Intercept)	0.68	26.59	< .001
	Role	-0.08	-4.23	< .001
Production ROI	(Intercept)	1.59	43.69	< .001
	Role	-0.10	-2.86	.006

Note. Estimates for aggregated effects of *Role: Attacker* on various outcome variables using linear mixed model with random effects *participant* and *dyad*.

Confirming hypothesis 2b, both parties reached the production threshold in the majority of rounds. Attackers were, however, more often successful (68.06%) than defenders (59.2%; *role* effect, $p < 0.001$; Table 4). As a result, over the 60-round period, attackers attained the production reward of 30 MU on average in five more rounds compared to defenders, resulting in a sizable difference in earnings, as we show below. Finally, attackers were more efficient in their production spending: For every unit invested in production, attackers earned on average 1.59 units, compared to 1.49 units for defenders (*role* effect, p = 0.006; Table 4). Thus, attackers and defenders differed in how much they were able to exploit the opportunity to create wealth through economic production.

Earnings and Wealth Disparity

Our final hypothesis (3) concerned earnings and wealth disparity. Resonating with the reduced expenditures on conflict, both attackers and defenders realized higher earnings in the PAD-C than in the AD-C (*game* effect, $p < 0.001$, Table 5; Figure 4c). At the same time, and due to the observed disparities in production efficiency and success alongside the unchanged likelihood for defenders to lose their endowment (and winnings), attackers earned disproportionately more than defenders (*game* × *role* effect, $p < 0.001$; Table 5). Having a production option, hence, decreased conflict expenditure but increased wealth inequality between attackers and defenders (*game* effect, $p < 0.001$; Table 5).

Table 5

Results of linear random intercept mixed models for earnings and inequality

Dependent Variable	Predictor	Estimate (b)	Test statistic (t)	p
Earnings	(Intercept)	15.83	20.84	< .001
	Game	14.09	12.95	< .001
	Role	-8.35	-11.25	< .001
	Game×Role	-7.09	-6.66	< .001
Inequality	(Intercept)	8.35	11.25	< .001
	Game	7.09	6.66	< .001

Note. Estimates for aggregated effects of *Game: PAD-C* and *Role: Attacker* on various outcome variables using linear mixed model with random effects *participan*t and *dyad*.

Cross-Round Dynamics in Conflict and Production

Previous research on repeated interactions between attackers and defenders indicates that especially defenders adjust their conflict investment as a response to attackers' aggression (De Dreu and Gross, 2018). We thus explored this possibility and examined how having production opportunities modulates such action-reaction tendencies. We found that defenders indeed conditioned conflict investment more strongly on their attackers' previous round behavior (in AD-C: $b = 0.35$, $p < .001$; in PAD-C: $b = 0.31$, $p < .001$; Table 6) than attackers conditioned investments on their defenders' previous round behavior (AD-C: $b = 0.10$, $p < .001$; PAD-C: $b = -0.02$, $p = .329$; Table 6). Furthermore, although attackers and defenders were less responsive to their opponents' previous round investment in the PAD-C than in the AD-C, this decrease in responsiveness was more pronounced for attackers than for defenders (the interaction effect *conflict investment defender lag 1 × game* when predicting attacker conflict investment was $b = -0.13$, $p < .001$; the interaction effect *conflict investment attacker lag 1 × game* when predicting defender conflict investment was $b = -0.06$, $p = .01$; Table 6). Possibly, the presence of a production opportunity allowed attackers more independence in their investment decisions, reducing their reliance on defender behavior. In contrast, the same production opportunity did not reduce this reliance for defenders, for whom unsuccessful defense was equally costly across conditions.

A similar pattern was observed when analyzing investment in production. Here too, defenders' production investment was strongly predicted by attackers' conflict investment in the previous round (*conflict investment attacker lag 1* effect, $p < .001$; Table 6), whereas attackers' investment in production was not predicted by defenders' past decisions (*conflict investment defender lag 1* effect, $p = .566$; Table 6). Our analysis therefore suggests that defenders' investment in production and conflict was constrained by their need to follow the attackers' conflict behavior more closely than vice versa. Because attackers could more freely decide to invest in production and/or predation, they reached the production threshold more often and earned relatively more than defenders.

Table 6

Results of linear random intercept mixed models for attacker and defender investment behavior predicted by opponents' conflict investment on the previous round

Dependent Variable	Predictor	Estimate (*b*)	Test Statistic (*t*)	*p*
Conflict investment	(Intercept)	7.06	10.80	< .001
attackers (AD-C)	Conflict investment defenders (lag 1)	0.10	5.65	< .001
Conflict investment	(Intercept)	5.95	13.74	< .001
defenders (AD-C)	Conflict investment attackers (lag 1)	0.35	24.06	< .001
Conflict investment	(Intercept)	5.18	15.90	< .001
attackers (PAD-C)	Conflict investment defender (lag 1)	-0.02	-0.98	.329
Conflict investment	(Intercept)	4.40	19.49	< .001
defenders (PAD-C)	Conflict investment attackers (lag 1)	0.30	19.18	< .001
Conflict investment	(Intercept)	6.99	13.36	< .001
attackers	Conflict investment defender (lag 1)	0.11	6.36	< .001
	Game	-1.76	-2.29	.023
	Interaction	-0.13	-4.94	< .001
Conflict investment	(Intercept)	5.89	16.86	< .001
defender	Conflict investment attackers (lag 1)	-0.64	-46.74	< .001
	Game	-1.47	-2.88	.005
	Interaction	-0.06	-2.59	.010
Production investment	(Intercept)	12.12	27.78	< .001
attackers (PAD-C)	Conflict investment defenders (lag 1)	0.01	0.57	.566
Production investment	(Intercept)	12.75	37.43	< .001
defenders (PAD-C)	Conflict investment attackers (lag 1)	-0.27	-14.57	< .001

Note. Estimates for effects of opponent previous round conflict investment on attackers and defenders conflict and production investment using linear mixed model with random effect *dyad*. Models 1 – 4 and 7 – 8 are treatment specific. Model 5 and 6 include both treatments and the effect of *Game: PAD-C.*

Conclusions and Discussion

The intention to increase wealth is among the key reasons for conflict – individuals, groups and nation states initiate and escalate predatory attacks on others to appropriate resources, to increase access to precious materials and territories controlled by others, or to benefit otherwise from what neighbors hold and produce. Even the mere anticipation of such predatory attacks can lead individuals, groups, and nation states to introduce a range of preventive measures, from legally-binding contracts to investing in military defense and pre-emptive strikes (Abbink & de Haan, 2014; Jervis, 1978). The inevitable arms-race set in motion by predatory attacks can be excessively costly, reducing (rather than increasing) economic wealth and prosperity in both conflict initiators and responders (De Dreu et al., 2022). Already in the simple attacker-defender contest studied here, attackers on average lost 20.87% of their original wealth, and defenders 62.63%. Whereas both sides started out equally wealthy, attackers on average earned 111.73% more post-conflict than their defending counterparts.

Next to using predatory attacks on others, individuals gain wealth through economic production, including technological innovation and investing in human capital. Individuals, groups, and nation states oftentimes face a tradeoff between investing in ‘peaceful’ economic production and ‘aggressive’ predation on what others have and produce. We modeled such tradeoffs under various cost levels and found that having rather than not having ‘peaceful’ production opportunities can indeed reduce overall conflict, and investment in predatory attacks in particular. We also found that when economic production becomes a more costly way to create wealth, predatory attacks become more rather than less likely. Our results therefore suggest that preventing renewed aggression would not only require opportunities for economic production but also opportunities that are comparatively easy to implement and realize. Indeed, both our model and our experiments revealed that while introducing costly production opportunities reduces the intensity of conflict, it does not eliminate predatory attacks. With the threat of predatory attacks looming, individuals continue to invest in defense and cannot fully focus on 'peaceful' creation of wealth through economic production (also see Antonakis, 1999). When peace is costly, wasteful conflicts emerge and persist, diminishing wealth and intensifying inequalities.

Using recent advances in theory on conflict in general and on asymmetric attacker-defender contests in particular, our findings integrate disparate literatures on the 'guns versus butter' tradeoffs that agents make (Carter & Anderton 2001; Durham et al., 1998; Lacomba et al., 2014) and on when and how natural resources and economic wealth can be a curse rather than blessing (van der Ploeg, 2011; Koubi et al., 2014). Combined, this allows us to conclude, first, that individuals invest in predatory attacks and, consequently, invest even more in defensive protection. Second, our theoretical results suggest that when economic production is a comparatively 'cheap' technology for wealth creation, predatory attack loses its appeal and wasteful conflict is reduced. Yet when economic production is comparatively costly, predatory attack gains in appeal and wasteful conflict re-emerges. Third, when peace is costly and conflict increasingly likely, especially those under attack become impoverished. Attackers are not only in the 'driver's seat' when it comes to initiating and intensifying conflict, they also suffer the least from costly opportunities for peace and wasteful conflict.

Limitations and Open Questions

Our conclusions need to be appreciated in light of several boundary conditions. First, our theoretical analysis relies on the Nash equilibrium prediction. Humans are bounded in their rationality and may hold social preferences and moral codes that may prevent them from investing in predatory attacks (see, e.g., De Dreu et al., 2019). Whereas our theoretical predictions were largely confirmed in our experiment, future work is needed to examine how social preferences and moral codes influence the tradeoff between creating wealth through more or less costly production on the one hand, and predatory aggression on the other. Second, we modeled economic production as a step-level technology for creating wealth. This made economic production similar to predatory attack, which also has a step-level success function. Alternative technologies for the economic production of wealth are conceivable, including linear relations between effort and return. The current theoretical model can be adapted to examine whether and how alternative technologies alter the tradeoffs between investing effort in economic production versus predatory attacks. Third, and although some of our hypotheses were inspired by work on international conflict, we tested predictions in stylized experimental contests between two individuals. While the strength of this approach lies in internal validity and enables us to draw causal inferences, further work is needed to examine whether and to what extent our experimental results generalize to more complex and multifaceted conflicts in which, next to investing in production, a range of behaviors other than investing in either attack or defense is possible (see also Mintz et al., 2006). Finally, our theory and experiment are limited to unitary actors akin to individuals involved in dyadic disputes or dictator-led nation states (also see De Dreu et al., 2021). Whether and to what extent the current model and conclusions can be extended to non-unitary actors like coalitions of several individuals, established groups, or democratic countries is an important question for future research.

Implications for Economic Theory and Conflict Resolution

Limitations notwithstanding, our findings contribute to several disparate literatures on economics and conflict resolution. As noted, both theoretically and empirically, we find some support for Keynes' intuition that agents lacking peaceful means to create wealth are more likely to become aggressive. Innovation alongside economic aid may be effective means to reduce the intensity of conflict in general and especially predatory capture (De Dreu & Gross, 2018; Maoz & Russett, 1993; Rousseau et al., 1996; Wittman, 2000). And yet, we also found that having (versus not having) possibilities to peacefully create and generate wealth did not lead to peaceful coexistence. Behaviorally, the frequency of predatory attacks and their success did not drop when production opportunities were present. This means that defenders lost their funds to attackers just as frequently, despite the presence of peaceful means of production, making successful attack no less costly for them. Furthermore, this unchanged frequency of conflict constrained defenders in the resources available for production, and they were consequently unable to accumulate as much wealth as their attackers did. Adding opportunities for costly peaceful production reduces the magnitude of conflict but not its likelihood or the waste it can cause.

Second, our theory and experimental evidence suggest qualifications to earlier work on the "natural resource curse" that showed that wealthier agents are more likely to become the target of aggression and, therefore, need to invest in defense (Brunnschweiler & Bulte, 2009; Hirshleifer, 1988, 1991; Olsson, 2007; van der Ploeg, 2011). Our analysis points to the possibility that this "natural resource curse" should emerge especially when wealth can be transferred easily to the victorious predator (also see Lujala et al., 2005). Relatedly, our results add to previous work on the "paradox of power" (Durham et al., 1998; Hirshleifer, 1991), which suggests that initially poorer (and thus weaker) agents are motivated to "fight harder" and thereby can improve their position relative to their richer (and thus stronger) opponents. In other words, conflict can equalize ex ante differences in wealth and power. The present results suggest that role asymmetries – i.e., being an attacker or defender – can qualify these insights, especially when agents have 'peaceful' alternatives to produce wealth. Specifically, because defenders "fight harder" overall, they are constrained in what they can invest in production (also see Grossman & Kim, 1996a, 1996b). To secure their existing wealth, defenders need to accept decreased productive capacity. The possibility of being attacked requires defenders to reduce their investment in production, and herein lies another reason for a possible reduction in ex ante wealth differences between (poor) attackers and (rich) defenders. Our analysis thus suggests that the very threat of outside hostility may lower both the ability and motivation to invest in, for example, innovation and product development (also see Aghion et al., 2005; Brown et al., 2017; Chemmanur & Tian, 2018; Conti, 2014).

Coda

Pioneering thinkers like John Stuart Mill and Adam Smith already distinguished between two opposing means aimed at increasing individual wealth: peaceful production and attempts to appropriate resources from others. To quite some extent, the science of economic production developed in relative isolation from the study of economic and political conflict. Only recently have efforts been made to integrate these lines of inquiry and start addressing the dynamic interplay between investing in economic production on the one hand and in predatory capture and protective defense on the other. Here we show that this interplay evolves dramatically differently when production is cheap versus costly, incentivizing versus dis-incentivizing conflict expenditure. Our experiment provided initial support for these possibilities, and revealed that adding (costly) production options to create wealth and prosperity in a peaceful way reduces only some aspects of conflict. Indeed, it reduced the magnitude, but not the frequency of investing in conflict, with defenders facing defeat at a rate similar to situations without peaceful alternatives to aggression. Finally, and even though costly production options reduced the intensity of conflict, they also increased wealth disparities, potentially setting the stage for future conflicts between haves and have-nots.

Chapter 4 - Unpredictable Futures, Parochial Pro-Sociality, and Intergroup Conflict

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Abstract

Groups experience carrying-capacity stress when returns from local club goods become unpredictable which may threaten group prosperity. Although we know that humans dislike uncertainty and find unpredictability stressful, how groups respond to unpredictable futures is unclear: A small body of work has found that carrying-capacity stress associates with increased group solidarity and parochial cooperation, but also with competition and intergroup conflict. Here we reconcile these seemingly contradictory findings in experiments in which individuals could contribute to local club goods with (un)predictable returns, and to conflict by investing in either out-group attacks or in-group defense. We find that individuals contribute less to their club goods and invest more in out-group attack when club goods provide unpredictable rather than predictable returns. As a result, individuals invest more in in-group defense and less in local club goods when their neighboring rivals have club goods with unpredictable returns. Findings reveal how increasing uncertainty, also arising in the wake of global climate change and geo-political volatilities, relate to cooperation within and competition and conflict between groups of people. Helping groups to reduce their carrying-capacity stress and to sustain themselves can prevent intergroup conflict and violence.

Keywords: behavioral ecology, cooperation, intergroup conflict, social welfare

Introduction

Climate change and geo-political instabilities at the global level can create local carrying-capacity stress – situations in which groups of people expect to have fewer resources than needed or are uncertain whether they can support themselves and their groups in the future (Read & LeBlanc, 2003; Kenneth & Marwan, 2015). For example, increased likelihood of flooding or prolonged droughts makes agricultural yields more unpredictable and create uncertainty about food supply. Price inflation and macro-economic volatilities can undermine the expected returns from collective pension funds, creating uncertainties about future income at both the individual and group-level (Bloom, 2009).

How groups respond to carrying-capacity stress is poorly understood. Climate science and studies in political geography have repeatedly observed associations between environmental deterioration and unpredictability – key factors underlying carrying-capacity stress – and increased prevalence of intergroup conflict and violence (De Dreu, Gross & Reddmann, 2022; Ember & Ember, 1992; Hsiang, Burke, & Miguel, 2013; Lee, 2018; O'Loughlin, Linke & Wimer, 2014; Schleussner, Donges, Donner & Schellnhuber, 2016; Von Uexkull, Croicu, Fjelde & Buhaug, 2016). At the same time, environmental disasters alongside threat of physical harm can provide a 'common fate' that binds individuals to their groups, resulting in increased group cohesion and solidarity (Calo-Blanco, Kovářík, Mengel, & Romero, 2017; Lojowska, Gross & De Dreu, 2023). It thus seems that carrying-capacity stress deteriorates intergroup relations and sparks conflict while at the same time, increases solidarity and cooperation within and perhaps between groups of people.

To reconcile these seemingly contradictory findings, and to uncover the behavioral mechanisms producing (macro-level) linkages between carrying-capacity stress, conflict and cooperation, we examined social decision-making in experimental contests between small groups that allow to systematically manipulate uncertainty, cooperation opportunities, and conflict success functions in a controlled environment. Our findings suggest that carrying-capacity stress deteriorates intergroup relations when and because individuals selectively care for in-group survival and prosperity. With such parochial pro-sociality emerging as a root cause of intergroup conflict, results also may shed light on how different policies and institutions can help groups to reduce carrying-capacity stress and prevent social unrest and political violence outside of the laboratory.

Carrying-Capacity Stress and Parochial Pro-sociality

To sustain and support themselves and their members, groups need resources such as food and territory alongside club goods that provide, e.g., for healthcare, education, and group defense. Carrying-capacity stress emerges when group members' individual and collective needs and desires exceed resource availability. This can happen when resources are no longer supplied, for example when trade relations break down or when harvests fail. It can also happen when territories shrink because of rising sea-levels or deteriorate because of global warming (see e.g., Tyler et al., 2021). Carrying-capacity stress emerges too when resource supply and returns from club goods become erratic and unpredictable (Bloom, 2009; Duncan, 1972; Ellis, Figueredo, Brumbauch & Schlomer, 2009). Previous research on decision making has shown that individuals usually dislike unpredictability and invest cognitive and physical energies to reduce uncertainties and create stable and predictable futures (Kruglanski, Pierro, Mannetti, & De Grada, 2006; Landay, Kay & Whitson, 2015). This aversion to risks and uncertainty may also play an important role for group behavior. For example, when collective pastures provide for future returns to individual herders that are certain and predictable, each may contribute time and energy to its maintenance. But when such returns become unpredictable, for example because of prolonged draughts or excessive rainfall, individual herders may become more hesitant to contribute time and energy to the maintenance of their collective pastures. When returns on local club goods become unpredictable, individuals may consider and invest in alternative means that serve themselves rather than the collective (e.g., Gross, Veistola, De Dreu & Van Dijk, 2021).

In sum, when future returns from local club goods become unpredictable (providing sometimes excellent and sometimes meager group benefits), individual contributions to their local club goods may decrease, ultimately leading to a classic 'tragedy of the commons' in which group members are worse off collectively than when they had made contributions. If true, we would see that carrying-capacity stress undermines group-level cooperation to the degree that groups may dissolve (e.g., Gustafsson, Biel & Gärling, 2000; Messick et al., 1988; Rapoport et al. 1993; Van Dijk et al., 1993; Wit & Wilke, 1998). And yet, research has also provided some evidence that environmental disasters and external threats can increase rather than reduce parochial pro-sociality – external threat and unpredictability increases within-group commitment and solidarity (De Dreu, Gross & Reddmann, 2022; Hogg, 2002; Barth, Masson, Fristsche & Ziemer, 2018) alongside willingness to contribute personal resources to group-benefitting club goods (Lojowska, Gross & De Dreu, 2023).

Rather than reducing group-level cooperation, one possible alternative response to carrying-capacity stress may be for individuals to seek alternative means to sustain individual and group prosperity. Next to reducing their contributions to the maintenance of their common pastures, the herders in our example may expand their territorial reach and venture into new areas to feed their livestock to provide for additional and perhaps more predictable group-level income (Sharif et al., 2019). Possibly, these new feeding areas belong to no one and can be freely accessed. Possibly, however, the resources needed to relax the group's carrying-capacity stress are held and used by other groups and capturing them may require hostile attacks on neighboring out-groups (De Dreu, Gross, Farina & Ma, 2020). If true, we would see that carrying-capacity stress, while reducing cooperation towards local club goods with uncertain returns, increases participation in collective aggression of out-groups.

Evidence for this possibility would provide a mechanistic explanation for the observed associations between global climate change and environmental shocks on the one hand, and political violence and intergroup conflict on the other (De Dreu, Gross & Reddmann, 2022; Ember & Ember, 1992; Hsiang, Burke, & Miguel, 2013; Lee, 2018; O'Loughlin, Linke & Wimer, 2014; Schleussner, Donges, Donner & Schellnhuber, 2016; Von Uexkull, Croicu, Fjelde & Buhaug, 2016).

The Present Study: Overview and Hypotheses

To examine the possibility that individuals in groups under carrying-capacity stress, operationalized as more uncertain returns from their group's club goods, increase their energy in competing for resources with other groups, we created an experimental model in which six individuals were nested in two groups of three. Within each group, individuals were given an endowment from which they could make contributions to their local club good. Contributing to the club good was personally costly, yet benefitted group welfare (creating the classic social dilemma of group cooperation). Individuals made investment decisions across a series of trials. Across trials we manipulated whether the group benefit from club good provision was predictable or unpredictable, as a manipulation of the group's carrying capacity stress. Importantly, across trials, the expected value of the group's club good was identical. We therefore only manipulated the (un)predictability of cooperation returns.

In addition to their club goods, individuals could also contribute to a contest with the other group. One group within this intergroup contest was designated the 'attacker' and the other the 'defender' (De Dreu et al., 2016, 2022; Gross et al., 2022). Individual investments in conflict were non-recoverable, yet when individuals in the attacker group collectively invested more than individuals in the rival defender group, the attacker group would win the contest and earn the defenders' revenues from their local club good, alongside any non-invested resources. When investment in out-group attack did not exceed that in in-group defense (i.e., defender groups were successful in defending themselves), individuals on both sides kept their non-invested resources and revenues from their local club good.

Grounded in the idea that humans are risk averse (Kahneman & Tversky, 1979), we predicted lower contributions to club goods with unpredictable rather than predictable group benefit for both attacker (Hypothesis 1a) and defender groups (Hypothesis 1b). Earlier studies have shown that individuals invest on average less in out-group attack than in in-group defense, and that out-group attacks are often unsuccessful (i.e., defenders 'survive' roughly 7/10 attacks; De Dreu, Gross, Meder et al., 2016, De Dreu et al., 2022; Gross, De Dreu & Reddmann, 2022; Zhang, Gross, De Dreu & Ma, 2019). We expected to replicate that attacker groups are less often victorious than defender groups (Hypothesis 2) because group-level investment in out-group attack is less strong than in in-group defense (Hypothesis 3). Crucially, however, we also predicted that individuals invest more in out-group attacks when their local club good provides unpredictable rather than predictable returns (Hypothesis 4a). Because more intense out-group attacks force defenders to invest more in conflict, we anticipated stronger in-group defense (Hypothesis 4b), and reduced contributions to the defender group's local club good (Hypothesis 4c), when the attacker group's local club good provided unpredictable rather than predictable returns.

Method

Ethics and Participants

The experimental design and hypotheses were preregistered (https://aspredicted.org/FPM_YJ8) and approved by the Psychology Research Ethics Board of Leiden University (Protocol #CEP19-0909/455). Participants provided written informed consent and received full debriefing upon conclusion of the study. The experiments did not involve deception and participants received a €9.50 show-up fee and an additional performance-based payment (on average €6.40, range between €0.95 and €12.50; see below).

For each experimental session we invited six participants and randomly allocated them to a three-person aggressor and a three-person defender group. Individuals made decisions (contributions to their local club good, and investments in the intergroup contests) in four blocks of 20 trials each. The four blocks orthogonally manipulated whether the own and the other group's local club good provided predictable or unpredictable returns, and this was common knowledge to all participants.

Sample size was set a priori in line with earlier intergroup contests and public good provision experiments, with a target of 25 sessions of 6 persons each (De Dreu et al., 2016; De Dreu et al., 2022; Gross et al., 2022). In total we recruited 168 participants (130 female; age M = 21.88, SD = 3.17, range 18–36 years), resulting in 26 experimental sessions.

Experimental Procedures and Treatments

Upon arrival in the laboratory, participants were seated at computers in individual cubicles. After providing informed consent and demographic information about age and gender, participants in groups of six were randomly divided into a three-person attacker and a three-person defender group. Participants were informed that they would make a series of decisions about how to allocate an endowment of 30 Monetary Units (MU). It was explained that MU would be converted into additional payout after the session was completed, and that participants could keep their MU or contribute some or all of it to a local club good and to the intergroup contest.

Contributing to Club Goods with (Un)predictable Returns. For the local club good, it was explained that any MU contributed would provide a return to each member of their three-person group, themselves included. In two blocks of 20 trials each, the return would be set to 1.5, such that each unit contributed gave each group member 0.5 MU (the individual marginal per capita return, MPCR). Thus, when all three group members contributed their full endowment, the participants' earnings from the local club good with certain returns (return multiplier = 1.5) would be 3 x 30 x 0.5 = 45 MU. When the participant would not contribute anything, and the other two would contribute their full endowment, the participant would earn 2 x 30 x 0.5 = 30 MU added to their own endowment of 30, thus totaling 60 MU, while the two contributors would earn 30 MU each. Hence, while investing units to the club good was beneficial for the group, such cooperation could also be exploited by free-riding on the investments of other group members.

In two other blocks of 20 trials, the club good provided uncertain returns. The return multiplier by trial was randomly set at either 0.5 or 2.5, yielding an MCPR of 0.16 and 0.83 respectively, with an average expected return of (0.16 + 0.83) / 2 = 0.5. Here, earnings per participant would be between 15 MU and 75 MU when all participants contributed fully. In the situation where one participant would contribute nothing while the other two contributed fully, the total pay-off for the non-contributing participant would be between 10 + 30 = 40 MU and 50 + 30 = 80 MU while the contributing participants would earn either 10 MU or 50 MU. Because the MPCR was high (low) in half of the trials within these blocks, the expected value from contributing across all trials is identical to that in the blocks with a fixed return of 1.5 on each trial. Hence, from a simple expected value perspective, average potential club good returns across trials were identical across the blocks. What we manipulated was the predictability of these returns – whether they were fixed across trials or could vary from one trial to another.

Participants were informed about the return multiplier at the beginning of each block. Hence, they would know whether the MPCR was fixed or would randomly vary between the lower and upper value. They were also explained that the other group also had a local club good to contribute to, and that for each block of trials they would be informed also whether the other group's local club good would have a fixed or variable MPCR.

Investing in Attacker-Defender Contests. Following the instructions about club good provision, participants were informed that in addition to their local club good, they could also invest MU in out-group attack or in-group defense (depending on which group-role they were assigned to). Instructions used neutral language throughout (e.g., groups were referred to as Group A and B, contributions were labeled investments, and we referred to out-group attack as group challenge and to in-group defense as group protection). We explained to individuals in the attacker group that investments in 'group challenge' would be wasted, yet that they would get all the MU earned in the other group (i.e., MU not invested + revenues from their local club good) when their investment in group challenge exceeded the other group's investment in group protection. Otherwise (i.e., when group protection was equal to or larger than group challenge), individuals on both sides would earn the revenues from their local club good, plus whatever they had not invested. Following these instructions, participants completed several comprehension checks that consisted of two complete scenarios for one round of the contest from the perspective of their role, with their group winning and losing the episode, respectively.

After all participants successfully completed all comprehension checks, they made decisions in 80 trials (four blocks of 20 trials each, see below). For each trial, they received 30 MU and indicated how much they want to keep for themselves, how much they want to contribute to their group's club good (i.e., within-group cooperation) and how much they want to invest in out-group attack (or in-group defense; i.e., the between-group conflict). In-between trials, participants received full feedback about how many MU their own and the other group invested into both club goods and conflict, the outcome of the conflict, how much the groups earned from club good provision and from conflict, and how much the individual had earned on that trial.

The 80 decision trials were divided in four blocks of 20 each. In one block, both the participant's own club good and the other group's club good had a fixed MPCR of 1.5. In a second block, the in-group's MPCR was fixed but the out-group's MPCR varied unpredictably. In a third block, the in-group's MPCR varied unpredictably, while the out-group's MPCR was fixed. In the fourth block, both the in-group's and the out-group's MPCR were unpredictable. The order in which blocks were presented was counterbalanced across groups.

After the main task, participants completed an incentivized Staircase Risk Elicitation Task to measure their risk preferences (Falk et al, 2016). Because individual-level risk preferences had no statistically significant relationship to participants' behavior in the main task, this measure is further ignored. Finally, participants were debriefed and paid. For the main task, the outcome of eight randomly selected rounds of decision-making were summed and then converted into Euro at a rate of 1 MU = 0.20€ (range €0.95 to €9.50; M = €4.76). For the additionally included Staircase Risk Elicitation Task, the conversion rate was 1 MU = 0.01€ (range €0.00 to €3.00; M = €1.64).

Dependent Variables. For each trial, we recorded how much of their 30 MU individuals contributed to their local club good (henceforth *club good contribution*), and contributed to conflict (henceforth *out-group attack*, or *in-group defense*, depending on the group-role). At the within-group level, we additionally computed (a) attacker and defender group's earnings from the local club good; and for attacker groups (b) *victory rates* (i.e., how often did out-group attack exceed in-group defense) and (c) *earnings from winning* the contest. Finally, we computed (d) *overall social welfare* relative to the maximum possible (i.e., 6 individuals x 30 units invested in local club goods x 1.5 expected return = 270 units), and (e) post-conflict *inequality* in earnings between attacker and defender groups.

Results

Hypotheses were tested with 3-level random intercept models with contribution and investment decisions (level 1) nested within participants (level 2) and participants nested within groups (level 3). The block in which both the attacker and defender group's club good provided certain returns (MPCR fixed at 1.5 for each trial, abbreviated as "C" for certain) served as our baseline (CC), while the attacker uncertain-defender uncertain (UU; "U" for uncertain), attacker uncertain-defender certain (UC), and attacker certain-defender uncertain (CU) conditions were included as dummy-coded variables. Formally, our statistical model can be expressed as:

$$\text{OutcomeVar}_{ijk} = \beta_{0jk} + e_{ijk},\ e_{ijk} \sim \text{N}(0, \sigma_e^2) \qquad \text{(level 1)}$$

$$\beta_{0jk} = \gamma_{00k} + u_{0jk},\ u_{0jk} \sim \text{N}(0, \sigma_u^2) \qquad \text{(level 2)}$$

$$\gamma_{00k} = \theta_{000} + \theta_{001} * \text{UU}_k + \theta_{002} * \text{UC}_k + \theta_{003} * \text{CU}_k + v_{00k},\ v_{00k} \sim \text{N}(0, v_u^2) \qquad \text{(level 3)}$$

where i = investment decisions, j = participants, and k = teams.

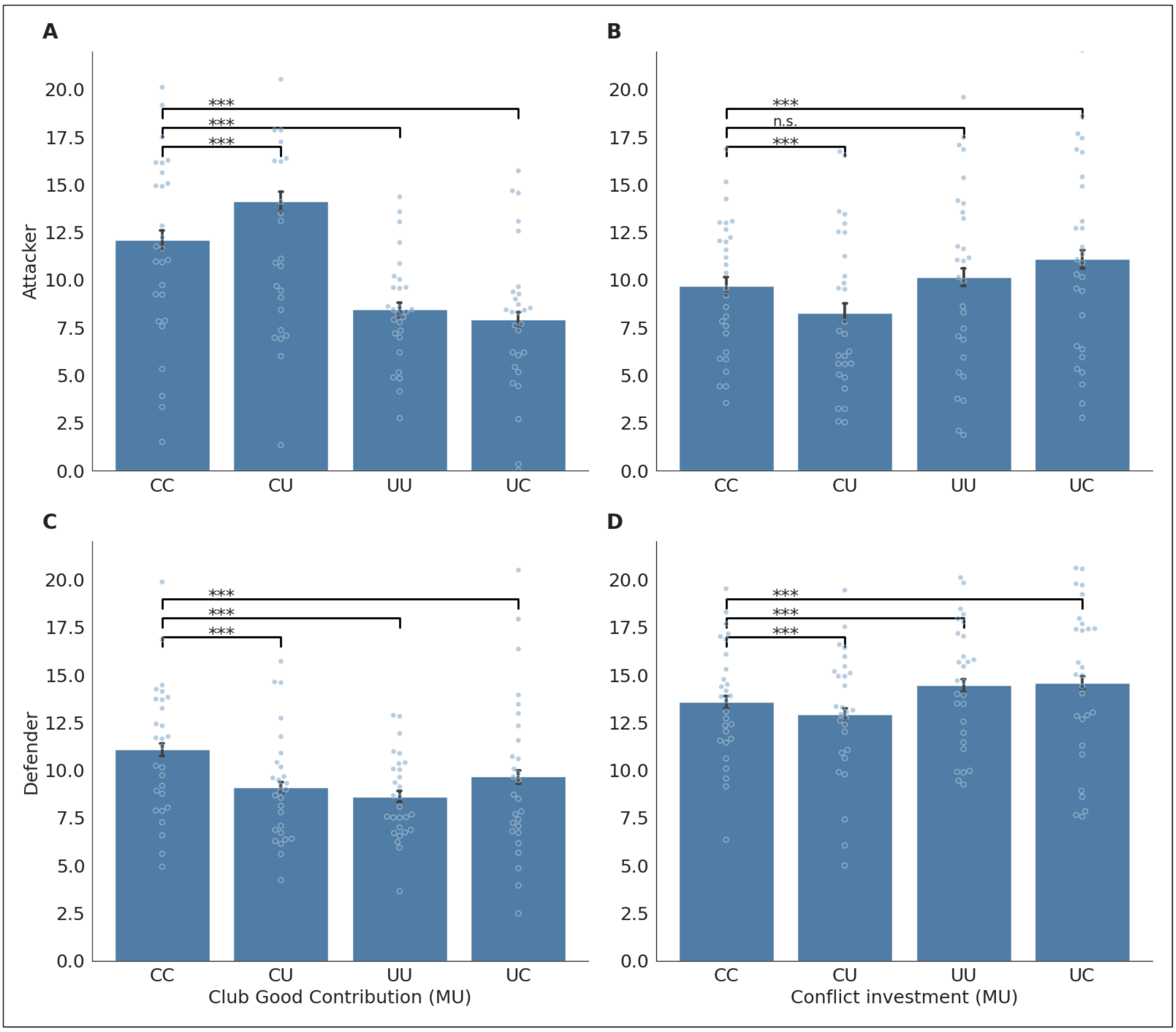
We performed our analyses using Python 3.9.16 for data processing and plotting, and R.351 for model fitting (Team, 2016). Linear mixed models were fitted using the lme4 package (Bates et al., 2015) and p-values were obtained using the lme4 extension package lmerTest (Kuznetsova et al., 2017).

Contributions to Club Goods and Conflict

Table 1 summarizes the regression models and results for participants' club good contributions and conflict investments. Focusing first on attacker groups, we find that when local club goods had uncertain rather than certain returns, individuals contributed less to their local club good (b = -4.17, t = -14.78, p < 0.001) and more to out-group attack (b = 1.40, t = 4.62, p < 0.001) (Fig 1A and 1B). This supports Hypotheses 1a and 4a. Interestingly, we also find that individuals invested more in their local club good (b = 2.01, t = 7.15, p < 0.001) and less in out-group attack (b = -1.40, t = 4.62, p < 0.001) when their defender group's local club good provides defenders with uncertain rather than certain returns (Fig 1A and 1B). This suggests that defender groups with reliable club goods become a more attractive target for aggression.

Figure 1

Average club good contributions and conflict investment for attacker and defenders



*Note***.** Average club good contributions and conflict investment for attackers (A and B, respectively) and defenders (C and D, respectively) when their groups' club goods had both certain (CC), certain and uncertain (CU), uncertain and certain (UC), or both uncertain (UU) returns. Shown are mean values (bars), standard errors (± 1 SE), aggregated investment by subject (dots). Contrasts are significant at *p < .05, **p < .01, and ***p < .001.

Table 1

Results of linear random intercept mixed models for club good contributions and investment in conflict

		Attackers		Defenders	
Dependent Variable	Predictor	Estimate (*b*)	Test statistic (*t*)	Estimate (*b*)	Test statistic (*t*)
Resources Kept	(Intercept)	8.19	8.22***	5.33	8.15***
	UC	2.76	9.87***	0.40	2.21*
	CU	-0.59	-2.11*	2.62	14.39***
	UU	3.23	11.51***	1.58	8.69***
Club Good Contributions	(Intercept)	12.11	16.88***	11.09	22.22***
	UC	-4.17	-14.78***	-1.42	-7.53***
	CU	2.01	7.15***	-1.98	-10.49***
	UU	-3.65	-12.97***	-2.47	-13.05***
Conflict Investments	(Intercept)	9.70	14.90***	13.58	25.14***
	UC	1.40	4.62***	1.02	5.63***
	CU	-1.42	-4.69***	-0.64	-3.52***
	UU	0.43	1.41	0.88	4.88***

Notes. The certain-certain (CC) condition serves as the baseline. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

For defender groups, we find that when local club goods provided uncertain rather than certain returns, individuals contributed less to their local club good (b = -1.98, t = -10.49, p < 0.001) (Figure 1C), confirming hypothesis 1b. They also invested less to in-group defense (b = -0.64, t = -3.52, p < 0.001) (Figure 1D). However, when their rivalling attackers had local club goods with uncertain rather than certain returns, defender groups contributed less to their own local club good (b = -1.42, t = -7.53, p < 0.001) and more to in-group defense (b = 1.02, t = 5.63, p < 0.001). These results may reflect an adaptive response to the attacker groups' stronger investment in out-group attacks when they had uncertain returns for their club goods. Indeed, while both out-group attack and in-group defense was predicted by previous round defenses and attacks (see Table 2), in-group defense is conditioned by previous round out-group attacks more than the other way around (attacks predicting next round in-group defense, b = 0.18, t = 22.01, p < 0.001 versus for in-group defense predicting next round out-group attack, b = 0.13, t = 7.28, p < 0.001). Taken together, these results support Hypothesis 4b and 4c.

Table 2

Results of linear random intercept mixed models for attackers' and defenders' investment behavior predicted by the opponents' conflict investment on the previous round

Dependent Variable	Predictor	Estimate (*b*)	Test Statistic (*t*)	*p*
Conflict investment attackers	(Intercept)	10.62	15.96	< .001
	Conflict investment defenders lag 1	0.13	7.28	< .001
	Round	-0.07	-13.45	< .001
Conflict investment defenders	(Intercept)	13.61	28.99	< .001
	Conflict investment attackers lag 1	0.18	22.01	< .001
	Round	-0.04	-10.93	< .001
Club good contributions attackers	(Intercept)	10.80	21.20	< .001
	Conflict investment defender lag 1	-0.09	-10.16	< .001
	Round	-0.01	-2.66	0.007
Club good contributions defenders	(Intercept)	12.22	15.74	< .001
	Conflict investment attackers lag 1	-0.10	-5.45	< .001
	Round	0	-0.99	0.324

Note. Estimates for effects of the opponents' previous round conflict investment on attackers' and defenders' conflict and club good investments using linear mixed models with random effect *team*.

Social Welfare Consequences

At the outset, individuals in both attacker and defender groups had an endowment of 30 MU, for a total collective welfare of $6 \times 30 = 180$ units. Individuals could increase social welfare by contributing to their local club goods, up to a maximum of $180 \times 1.5 = 270$, or 45 units per individual. Engaging in conflict, however, also could reduce social welfare, as every unit invested in out-group attack or in-group defense would be wasted. Indeed, if all individuals contributed their full endowment to conflict, social welfare would be reduced to $180 - 180 = 0$. However, attacker but not defender groups could increase in-group welfare through successful out-group attacks – whereas units contributed to out-group attack would be wasted, victory would earn attackers the defender's non-invested resources alongside revenues from the defender's local club good. While conflict inherently reduces social welfare at the collective level, it can create wealth inequalities between (and within) groups of people.

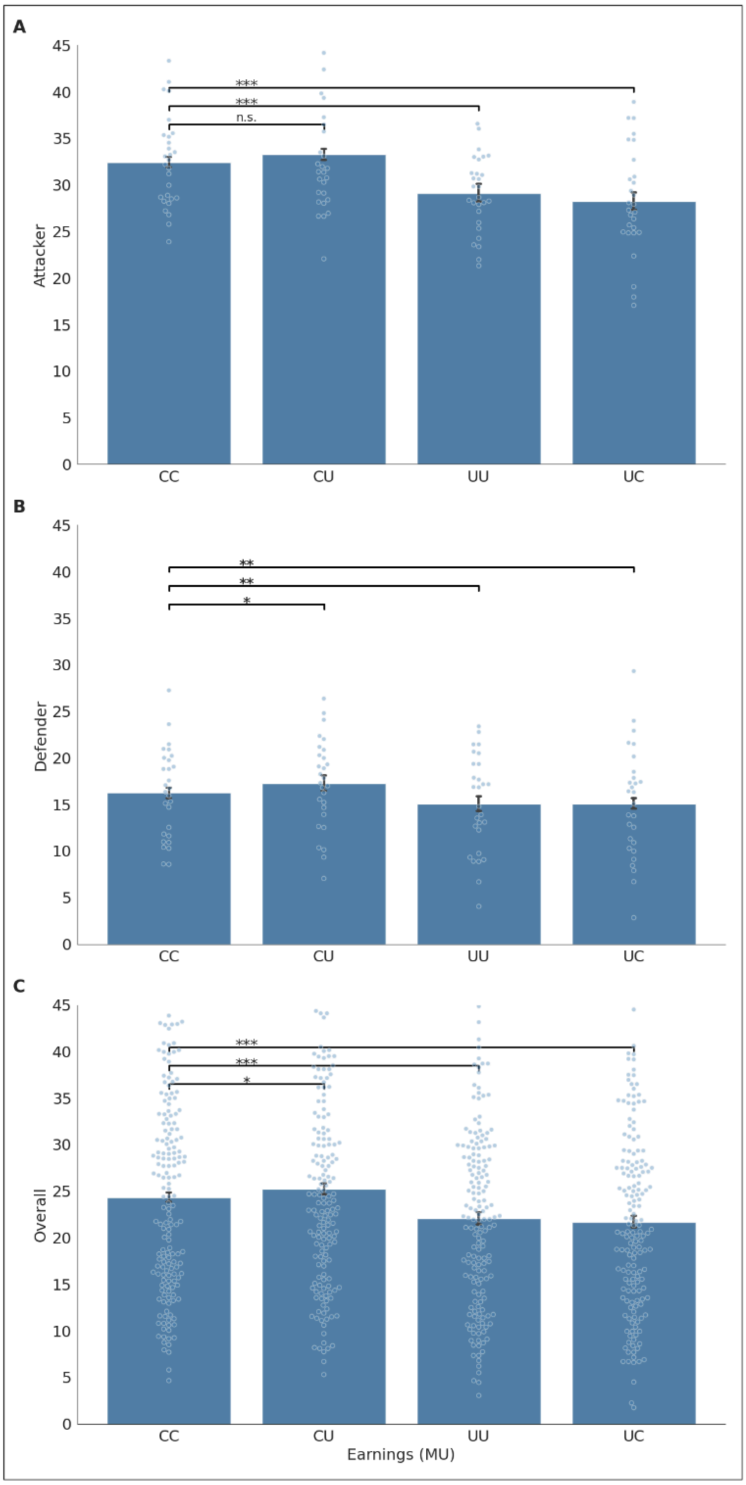
Table 3 summarizes results from regression models for earnings and attacker victory rate as dependent variables. Individuals in attacker groups earned significantly from local club good provision ($b = 18.36$, $t = 16.89$, $p < 0.001$), although less when the club good gave uncertain rather than certain returns ($b = -6.39$, $t = -13.88$, $p < 0.001$) and, interestingly, more when the defenders' club good gave uncertain rather than certain returns ($b = 3.02$, $t = 6.55$, $p < 0.001$; Figure 2A). This may follow from out-group attacks being less intense when defender club goods were uncertain, leaving attackers more resources to invest in one's own local club good. Indeed, fitting earlier findings in attacker-defender contests and confirming hypothesis 2 and 3, attacker groups invested less into out-group attacks than defenders into in-group defense (b = 4.08, $t = 7.23$, $p < 0.001$) and out-group attack was only successful in 25% of the trials, overall. Nonetheless, attackers earned an overall positive return from attack ($b = 5.91$, $t = 11.81$, $p < 0.001$). Whereas victory rate was not influenced by the uncertainty of the attacker's local club good ($b = 0.00$, $t < 1$), it was significantly lower when the defender's local club good gave uncertain rather than certain returns ($b = -0.05$, $t = -2.18$, $p < 0.029$). And indeed, the income from victorious out-group attacks was lower when the defender's club good gave uncertain rather than certain returns ($b = -1.62$, $t = -4.42$, $p < 0.001$).

Turning to defender groups, we observed the mirror image for earnings (Figure 2B). Specifically, individuals in defender groups earned significantly from their local club good ($b = 12.31$, $t = 18.09$, $p < 0.001$), yet less when either their own, or the attacker's local club good gave uncertain rather than certain returns ($b = -1.39$, $t = -3.45$, $p < 0.001$, and $b = -1.27$, $t = -3.15$, $p = 0.002$). Whereas the former reduction can be explained by reduced contributions by individual defenders, the latter reduction can be explained by the increased need to invest resources in in-group defense to protect against comparatively intense out-group attacks that were motivated by the attacker groups' uncertain-return local club good.

When considering these dynamics of club good contributions and conflict, overall social welfare was significantly reduced when club good uncertainty to either attacker or defender groups was present (Figure 2C). In particular, average overall earnings declined significantly when both the attacker and defender group faced an uncertain club good ($b = -2.26$, $t = -6.26$, $p < 0.001$) and when the attacker groups' club good returns were uncertain while the defenders' club good returns were certain ($b = -2.66$, $t = -7.39$, $p < 0.001$). In contrast, when attackers' club good returns were certain, but the defenders' club good returns uncertain, overall earnings increased ($b = 0.92$, $t = 2.55$, $p < 0.011$). These results, together with the conflict dynamics, illustrate that the decline in social welfare was specifically caused by attacker groups being confronted with uncertain club good returns, leading them to engage in out-group aggression and more wasteful group conflict.

Figure 2

Average earnings by condition



*Note***.** Average attacker (A), defender (B), and overall (C) earnings when the groups' club goods had certain (CC), certain and uncertain (CU), uncertain and certain (UC), and uncertain (UU) returns, respectively. Shown are mean values (bars), standard errors (± 1 SE), aggregated investment by group (dots). Contrasts are significant at *p < .05, **p < .01, and ***p < .001.

Table 3

Results of linear random intercept mixed models for individual and social welfare

		Attackers		Defenders	
Dependent Variable	Predictor	Estimate (*b*)	Test statistic (*t*)	Estimate (*b*)	Test statistic (*t*)
Earnings from club good	(Intercept)	18.36	16.89***	12.31	18.09***
	UC	-6.39	-13.88***	-1.39	-3.45***
	CU	3.02	6.55***	-1.27	-3.15**
	UU	-5.48	-11.89***	-2.70	-6.68***
Victory rate	(Intercept)	0.25	10.35***		
	UC	-0.05	-2.18*		
	CU	-0.03	-1.24		
	UU	0.00	0.15		
Earnings from Victory	(Intercept)	5.91	11.80***		
	UC	-0.54	-1.49		
	CU	-1.62	-4.42***		
	UU	-1.09	-2.97**		
Overall Earnings	(Intercept)	32.45	40.81***	16.26	21.58***
	UC	-4.17	-7.62***	-1.15	-2.47**
	CU	0.81	1.48	1.03	2.19*
	UU	-3.34	-6.10***	-1.18	-2.51**

Note. The certain-certain (CC) condition serves as the baseline. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Parochial Pro-Sociality or Selfish Freeriding

Results thus far provide support for the prediction that when the local club good provides uncertain rather than certain return on investment, individuals in attacker groups reduce club good contributions and increase contributions to out-group attack. However, external threat and unpredictability may not make individuals more or less selfish, but rather redirect behavior to alternative means to benefit the in-group, out-group attacks included. Both club-good cooperation, as well as out-group attack introduces freeriding incentives. Group members can fare better when others cooperate and invest into their group's club good, while they keep their resources. Similarly, attacking group members can benefit from winning the conflict, even if they contributed little. To see whether unpredictability merely shifts the mode of group cooperation (from in-group, club good cooperation to coordinated out-group attacks), we concluded our analyses by considering the extent of freeriding across conditions in attacking groups. To this end, we define freeriding as not contributing anything to local club goods (i.e., freeriding on the club good) or not investing anything to conflict (i.e., freeriding on conflict participation) on a given round.

Results are summarized in Table 4. Compared to situations in which their local club good provided certain returns, individuals in attacker groups more often made zero contribution to the local club good when it gave uncertain returns ($b = 0.31$, $t = 7.31$, $p < 0.001$; Table 1). Importantly, at the same time, they also made less often zero contribution to out-group attack ($b = -0.20$, $t = -3.90$, $p < 0.001$; Table 1). While this suggests that uncertain local club goods indeed shifted the target of one's group behavior, the overall level of freeriding – decision rounds in which individuals kept their full endowment and contributed nothing to either groups' actions – was higher when local club goods provided uncertain rather than certain return ($b = 0.14$, $t = 4.27$, $p < 0.001$).

Table 4

Results of linear random intercept mixed models for club good non-contributions and conflict non-investments and freeriding

		Attackers		Defenders	
Dependent Variable	Predictor	Estimate (*b*)	Test statistic (*t*)	Estimate (*b*)	Test statistic (*t*)
Club Good Non-Contributions	(Intercept)	0.63	6.26***	0.26	4.70***
	UC	0.31	7.31***	0.12	4.28***
	CU	0.36	0.08	0.06	2.14*
	UU	0.12	2.77**	0.05	1.89
Conflict Non-Investments	(Intercept)	1.22	11.32***	0.20	5.67***
	UC	-0.20	-3.90***	-0.10	-4.72***
	CU	0.26	4.89***	-0.05	-2.40*
	UU	-0.16	-2.98**	-0.09	-4.29***
Freeriding	(Intercept)	0.32	4.03***	0.06	3.85***
	UC	0.14	4.27***	-0.04	-3.55***
	CU	0.01	0.32	-0.02	-2.10*
	UU	0.10	3.09**	-0.02	-1.61

Note. The certain-certain (CC) condition serves as the baseline. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Like attackers, defending group members more often contributed zero to their club good ($b = 0.06$, $t = 2.14$, $p < 0.033$) and less often invested zero into conflict ($b = -0.05$, $t = 2.40$, $p < 0.016$) when their club good provided uncertain returns. The overall level of freeriding for defenders, however, did not increase but even declined somewhat ($b = -0.02$, $t = 2.10$, $p < 0.036$). A possible explanation is that unlike for attacker group members, an overall break-down in contributions under uncertainty for defenders is prevented by a continued need to invest into defense against potential attacks.

Coordination on Club Good Contributions and Conflict

Certain club good returns might facilitate coordination on club good contributions within groups. Conversely, uncertain club good might make it easier for group members to focus on conflict, thereby increasing coordination on conflict investment. This should be true especially for attacker groups who have an incentive to gain resources through appropriation. To test for this possibility we computed, as an index of in-group coordination, the within-round intra class correlation for contributions.

Results for coordination are summarized in Table 5. Indeed, compared to baseline, attackers' coordination on club good contributions decreased when the club good provided uncertain returns ($b = -0.10$, $t = -6.58$, $p < 0.001$) whereas their coordination on attack increased ($b = 0.05$, $t = 6.72$, $p < 0.001$). On the defender side, group members likewise showed decreased coordination on their club good when returns turned uncertain ($b = -0.15$, $t = 12.01$, $p < 0.001$). Unlike attackers, however, defenders did not improve their coordination on contributions towards defense ($b = -0.04$, $t = -6.71$, $p < 0.011$), possibly due to not having the same incentive of gaining resources by appropriating from their opponent.

Table 5

Results of linear random intercept mixed models for club good and conflict coordination

		Attackers		Defenders	
Dependent Variable	Predictor	Estimate (*b*)	Test statistic (*t*)	Estimate (*b*)	Test statistic (*t*)
Club Good Coordination	(Intercept)	0.25	17.19***	0.20	15.18***
	UC	-0.10	-6.58***	-0.03	-2.19*
	CU	0.08	5.03***	-0.15	-12.01***
	UU	0.21	-13.46***	-0.23	-18.44***
Conflict Coordination	(Intercept)	0.13	12.69***	0.22	12.12***
	UC	0.05	3.41***	-0.04	-2.96**
	CU	-0.01	-1.04	-0.04	-2.54*
	UU	0.09	6.72***	-0.10	-6.71***

Note. The certain-certain (CC) condition serves as the baseline. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Conclusions and Discussion

Here, we confronted two teams with an attacker-defender contest. Both teams had the possibility to also increase their earnings peacefully through separate club goods. These club goods either delivered uncertain or certain contribution returns. Despite the expected value of club good contributions being the same under standard economic theory (assuming risk neutrality), we observed startling differences in behavior for both attackers and defenders. As hypothesized, when faced with uncertain returns from their local club goods, attackers reduced their overall contributions (H1a), displayed decreased coordination, and more frequently opted to invest nothing. In turn, they demonstrated improved conflict coordination and increased their overall investments in out-group attacks (H4a), being less likely to invest nothing into aggression. Not all resources saved from the break-down in club good contributions were moved into attack, however: Overall, attackers kept more resources and exhibited more free-riding when returns were uncertain. Similarly, defenders contributed less to their local club goods when faced with uncertain vs certain returns (H1b), kept more of their resources and increased their free-riding. We replicated earlier findings, showing that attacker groups are less often victorious than defender groups (H2) due to out-group attacks being overall less strong than in-group defense (H3). Indeed, defender groups exhibited a strategic response to increased aggression from attacker groups under uncertainty, investing more in in-group defense (H4b) and less in their local club good (H4c) when rival attackers had uncertain club good returns. Since defenders adjusted their defense spending to the aggression exhibited by attackers, attackers were not more successful under uncertainty despite increasing their attack investments. Due to the breakdown in contribution to their club good and their inability to increase their success at attack, attackers earned less under uncertainty than when club good returns were certain. Defenders' earnings likewise declined when either their own or the attacker's club goods was uncertain. Thus, environmental uncertainty increased wasteful conflict, leading to a decline in the overall social welfare, particularly when the attacker groups faced an uncertain club good.

Implications

Our study helps to integrate disparate findings on how groups respond to carrying capacity stress, bridging a gap between contrasting arguments in the literature. On the one hand, prior studies have shown that carrying capacity stress might lead to a classic tragedy of the commons, undermining group-level cooperation and potentially leading to group dissolution (Gustafsson, Biel & Gärling, 2000; Messick et al., 1988; Rapoport et al. 1993; Van Dijk et al., 1993; Wit & Wilke, 1998). On the other hand, research has shown that external threats and unpredictability might provide a 'common fate', enhance group cohesion and solidarity (De Dreu, Gross & Reddmann, 2022; Hogg, 2002; Barth, Masson, Fristsche & Ziemer, 2018), and increase group members willingness to contribute resources to group-benefitting club goods (Lojowska, Gross & De Dreu, 2023).

Our findings lend some support to the notion that uncertainty can contribute to the breakdown of club goods within groups. In our study, both attackers and defenders decreased contributions to their club good, reduced coordination, and increased free-riding when faced with an uncertain environment. And yet, we also found that uncertainty prompted attackers to capitalize on the chance to cooperate and coordinate on out-group aggression, instead, thus supporting the idea that carrying capacity stress and unpredictability can foster group commitment and solidarity when a suitable opportunity is present. Our research thus underscores the notion of parochial prosociality, demonstrating that individuals within groups flexibly contribute to their group's welfare through either peaceful within-group cooperation, or through aggressive intergroup competition. Carrying-capacity stress can, in this sense, tip the balance from pro-social contribution to local club goods, to pro-social contributions to out-group aggression (De Dreu et al., 2020).

Our findings can also provide a mechanistic explanation for the often-observed association between environmental deterioration and volatility – key factors underlying carrying-capacity stress – and heightened prevalence of intergroup conflict and violence (Ember & Ember, 1992; Lee, 2018; O'Loughlin, Linke & Wimer, 2014; Schleussner, Donges, Donner & Schellnhuber, 2016; Von Uexkull, Croicu, Fjelde & Buhaug, 2016). For example, a meta-analysis by Hsiang, Burke, and Miguel (2013), including 60 macro-level studies on climate change and conflict, discovered that a standard deviation change in temperature or rainfall was associated with a 14% increase in the likelihood of intergroup conflict. Our research can help to understand the behavioral underpinnings of this link, demonstrating experimentally how unpredictability in the environment can lead to a break-down of peaceful cooperation on club goods, increased outgroup aggression, intergroup competition, and an overall escalation in wasteful conflict.

Our study therefore underlines the need for governments and international organizations to recognize the interconnected nature of environmental issues that may negatively influence the return on club goods, cooperation within societies, and the potential for violent intergroup conflict. Policymakers and stakeholders might focus on developing strategies that help groups to mitigate environmental stressors and promote sustainable resource management, especially in regions where situational factors suggest that the opportunity for outgroup aggression and conflict is present.

Limitations and Open Questions

Our study tested the impact of (un-)certainty on within-group cooperation and intergroup conflict using a stylized experimental contest game – the 3-vs-3 group attacker-defender contest with club goods – in a controlled laboratory setting. The strength of this approach lies in its internal validity and enables us to draw causal inference about the effects of (un-)certain returns on cooperation and conflict within this setting. While providing valuable insights, this approach, however, can, of course, not fully capture the intricacies of real-world situations. Factors to think about when generalizing our findings to real-world contexts include multifaceted, ambiguous consequences of environmental and economic change, dynamics within large groups characterized by multilayered social organization, and intergroup relations affected by complex interdependencies and long-standing and nuanced histories. As pointed out, however, our research complements an already existing body of work on the macro-level effects of environmental change and conflict, and thus provides a valuable experimental addition that extends our understanding of the behavioral dynamics at play.

One obvious limitation that group members faced in our experiment was the inability to directly coordinate their contributions towards either their club good or conflict. Indeed, groups in our experiment showed relatively low levels of coordination, an effect that was further exacerbated when club good returns turned uncertain. Thus, a possible extension of our paradigm would be to introduce institutions that might improve group members ability to coordinate, such as leadership in the form of a “first mover” or the ability to communicate between group members. Previous experimental research employing pure intergroup contests has demonstrated that both leadership (e.g., De Dreu et al., 2016) and the ability to communicate (e.g., Cason et al., 2012, 2017) reduce free-riding and lead to an overall escalation of conflict. In our context, an intriguing question is if such institutions could help group members to overcome the observed breakdown in club good contributions under uncertainty (which, after all, have the same expected utility as the certain environment), or, as observed in previous studies, if these mechanisms would simply intensify out-group attacks and exacerbate intergroup conflict further. The former would resonate with previous experimental work showing, for example, that communication and punishment can be effective means to prevent overharvesting in common pool resource dilemmas (Ostrom et al., 1990).

Conclusion

Our study provides insight into the effects of environmental (un-)certainty and the dynamics of within-group cooperation and intergroup conflict. Our findings reveal that environmental uncertainty leads to a breakdown in club good contributions, reducing coordination and increasing free-riding, while also promoting out-group aggression and leading to an escalation in intergroup conflict. Our research complements existing macro-level research on the association between environmental change and conflict, elucidating the behavioral underpinnings of this relationship. Future research could explore factors that might help groups to peacefully cope with and adapt to the effects of environmental uncertainty, potentially focusing on institutions that improve communication and coordination within groups.

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There are no truly infinite games in life. And so, while this particular game has come to an end, I look back with profound gratitude to the experience and the people who were a part of it. May many of you be part of exciting games ahead!

Curriculum Vitae Lennart Reddmann

Lennart Reddmann was born on 10th April 1988 in Solingen, Germany. In 2008, he received his Abitur from the August-Dicke-Gymnasium in Solingen. After completing his civilian service, Lennart went on to study Psychology in Groningen, Netherlands, and received his Bachelor's degree in 2013. He then had a brief stint as a consultant for an Executive Search firm in Berlin, Germany. In 2015, he returned to the Netherlands to pursue his Master's studies in Social & Organisational Psychology at the University of Leiden, obtaining his degree in 2017. From 2017 to 2018, he worked as a research assistant with various researchers in the Social, Economic, and Organisational Psychology Department at Leiden University. In 2018, he began his PhD under the supervision of prof.dr. Carsten de Dreu and prof.dr. Jörg Gross, investigating peaceful alternatives in asymmetrical conflict situations, and completed his dissertation in 2023.

Samenvatting

Conflict is een fundamenteel aspect van de menselijke samenleving en bepaalt de trajecten van individuen, groepen en naties. Binnen groepen kan conflict de sociale hiërarchie verstoren en herordenen, inkomensongelijkheid oplossen of aanwakkeren, en bestaande sociale normen omverwerpen. Tussen groepen, conflict vormt populaties, beïnvloedt het de vorming van groepsidentiteiten, en kan het leiden tot langdurige grieven tussen volkeren. Echter, niet alle conflicten vinden plaats tussen gelijke partijen. Conflict ontstaat vaak wanneer de ene partij iets wil dat de andere probeert te voorkomen, zoals een militaire invasie tussen twee landen of een vijandige overname in de zakenwereld. Hoewel eerder onderzoek veel inzicht heeft gegeven in de dynamiek van dergelijke asymmetrische conflicten, blijft de vraag hoe we deze conflicten kunnen verminderen of oplossen, en specifiek, hoe we de aanvallende partij kunnen weerhouden van agressie? Dit proefschrift beoogt deze vraag te beantwoorden in drie empirische hoofdstukken, gebruikmakend van zowel economische theorie als experimentele spellen.

Hoofdstuk 2 gaat in op een van de strategieën die een verdedigende partij kan gebruiken wanneer ze geconfronteerd worden met agressie. Een defender kan niet alleen kiezen om te vechten of te vluchten bij confrontatie door een attacker, maar ook proberen de agressieve partij te "appease" door een vrijwillige overdracht van middelen. Historische voorbeelden, zoals de mislukte appeasement van Nazi-Duitsland door Groot-Brittannië of het succesvolle tribuutsysteem van China, benadrukken het risico van uitbuiting van dergelijke appeasementstrategieën, maar ook hun potentieel om relaties te stabiliseren. Door middel van twee experimenten onderzoek ik of defenders zouden kiezen voor het overdragen van middelen als een gebaar van appeasement en of dergelijke overdrachten agressie effectief verminderen. De eerste studie vergelijkt de attacker-defender contests (AD-C), een model van asymmetrisch conflict, met een uitgebreide versie, de Transfer Attacker-Defender Contest

(TAD-C), die een extra stadium omvat waar defenders een deel van hun tegoed kunnen overdragen aan de attacker. De tweede studie gebruikt een strategy method van de TAD-C voor zowel attackers als defenders om de resultaten te repliceren en om het besluitvormingsproces van de participanten beter te begrijpen. Over het algemeen suggereren de resultaten dat asymmetrisch conflict inderdaad kan worden verlicht door de verdedigende partij de optie te bieden om een deel van hun middelen over te dragen aan de attacker. De resultaten van het eerste experiment waren echter gemengd: een deel van attackers buitte overdrachten uit door de defender aan te vallen. Experiment 2 toont aan dat dit gedrag deels wordt gemodereerd door social value orientation.

Hoofdstuk 3 onderzoekt de potentie van economische productie kansen als een middel om asymmetrisch conflict en agressie te verminderen. Voortbouwend op theorieën van politieke economie en eerder onderzoek naar conflict, stelt dit hoofdstuk dat het bieden van alternatieve mogelijkheden voor het genereren van rijkdom pogingen tot agressie en het daaruit voortvloeiende conflict kan ontmoedigen. Hoofdstuk 3 biedt zowel een spel-theoretische analyse als een experiment om dit idee te toetsen. Voor beide vergelijk ik de AD-C met een uitgebreide versie, de Production Attacker-Defender Contest (PAD-C). In de PAD-C hebben spelers de optie om een deel van hun middelen te investeren in productie om een uitbetaling te bewerkstelligen. Om succesvol te zijn met een productie-investering, moet een speler een "production threshold" halen of overschrijden. De spel-theoretische analyse suggereert dat de mate waarin productie gemakkelijk kan worden bewerkstelligd een cruciale rol speelt in het bepalen van de niveaus van agressie en de verdeling van rijkdom: wanneer drempels relatief laag (hoog) zijn, is er een afname (toename) van agressie en verdediging, met als gevolg een minder (meer) ongelijke verdeling van rijkdom. Het gedragsexperiment bevestigt dat het bieden van kansen voor economische productie de intensiteit van attacker agressie en conflict inderdaad kan verminderen. Beide partijen blijven echter met hoge frequentie investeren in conflict, en de aanhoudende noodzaak van defenders voor verdediging beperkt hun vermogen om in productie te investeren. Als gevolg daarvan nemen rijkdomsverschillen toe in het voordeel van attackers.

Hoofdstuk 4 onderzoekt de dynamiek van groepssamenwerking en -conflict onder voorwaarden van carrying-capacity stress. Om zichzelf en hun leden te ondersteunen en in stand te houden, moeten groepen samenwerken aan club goods om voedsel, goederen of diensten te produceren (zoals gezondheidszorg en onderwijs). Daarentegen kunnen groepen ook samenwerken aan het aanvallen en toe-eigenen van middelen van andere groepen of, als ze het doelwit zijn van dergelijke agressie, aan het verdedigen van zichzelf. Carrying-capacity stress ontstaat wanneer de collectieve behoeften van een groep de beschikbare middelen overstijgen of wanneer de opbrengsten van gedeelde middelen onvoorspelbaar worden. In Hoofdstuk 4 onderzoek ik of en hoe carrying-capacity stress in de vorm van onzekerheid rond de vreedzame productie van middelen via een club good gerelateerd is aan het ontstaan van agressie tegen buitenstaanders en conflicten tussen groepen. Via een experimenteel model konden deelnemers in groepen van drie bijdragen aan een lokaal club good of deelnemen aan een conflict met een andere groep. Om carrying-capacity stress te manipuleren, werd het groepsvoordeel van club good levering ofwel voorspelbaar of onvoorspelbaar gemaakt. De resultaten tonen aan dat onder onvoorspelbare condities attackers hun bijdragen aan het club good verminderen en hun agressie tegen buitenstaanders verhogen. Deze agressieve strategie is echter niet voordelig, omdat het leidt tot mislukte toe-eigeningspogingen en de inkomsten voor zowel attackers als defenders vermindert. Over het geheel genomen benadrukt dit hoofdstuk het belang van stabiele, voorspelbare opbrengsten uit gedeelde middelen bij het voorkomen van verspillend conflict en het bevorderen van algemeen welzijn.

Over het geheel genomen levert dit proefschrift een belangrijke bijdrage aan de bestaande literatuur over (asymmetrisch) conflict, en helpt het de vraag te beantwoorden hoe dergelijk conflict kan worden verminderd en hoe een aanvallende partij kan worden ontmoedigd tot agressie. In de loop van drie hoofdstukken, vind ik dat 1) zowel attackers als defenders vreedzame alternatieven voor het genereren van rijkdom benutten wanneer beschikbaar, 2) dit vermindert conflict en attacker agressie, maar roeit dit niet volledig uit, 3) beide partijen profiteren van de vermindering van conflict, echter, 4) vanwege de consistente kosten die gepaard gaan met het verdedigen tegen de dreiging van een aanval, profiteren attackers onevenredig veel van vreedzame alternatieven in vergelijking met defenders.

Summary

Conflict is a fundamental aspect of human society, shaping the trajectories of individuals, groups, and nations. Within groups, conflict can disrupt and reorder social hierarchies, resolve or foment wealth inequality, and overturn existing social norms. Between groups, conflict shapes populations, influences the formation of group identities, and can result in long-standing grievances between peoples. However, not all conflicts occur between equal parties. Conflict often arises when one party wants something that another tries to prevent, such as a military invasion between two countries or a hostile takeover in the business world. While previous research has shed light on many dynamics of such asymmetric conflicts, an open question remains: how can we reduce or resolve these conflicts, and specifically, how can we dissuade the attacking party from aggression? This dissertation aims to answer this question in three empirical chapters, utilizing both economic theory and experimental games.

Chapter 2 delves into one of the strategies a defending party might employ when confronted with aggression. Indeed, a defender might not only choose to fight or flee when confronted by an attacker but also attempt to "appease" the aggressive party through voluntary resource transfers. Historical examples, such as Britain's failed appeasement of Nazi Germany or China's successful tributary system, highlight the risk of exploitation of such appeasement strategies but also their potential to stabilize relations. Using two experiments, I examine whether defenders would opt to transfer resources as an appeasement gesture and whether such transfers effectively diminish aggression. The first study compares the attacker-defender contest (AD-C), a model of asymmetric conflict, with an extended version, the transfer attacker-defender contest (TAD-C), which includes an additional stage where defenders can transfer some of their endowment to the attacker. The second study uses a strategy method of the TAD-C for both attackers and defenders to replicate the results and to

better understand participants' decision-making. Overall, results suggest that asymmetric conflict can indeed be alleviated by providing the defending party with an option to transfer some of their resources to the attacker. However, results of the first experiment were mixed: a subset of attackers exploited transfers by aggressing the defender. Experiment 2 demonstrates that this behavior is, in part, moderated by social value orientation.

Chapter 3 examines the potential of economic production opportunities as a means to mitigate asymmetric conflict and aggression. Drawing from theories of political economy and previous conflict research, this chapter posits that providing conflicting parties with alternative means for wealth generation might deter attempts at aggression and the ensuing conflict. Chapter 3 offers both a game-theoretic analysis and an experiment to test this idea. For both, I compare the AD-C to an extended version, the production attacker-defender contest (PAD-C). In the PAD-C, players have the option to invest some of their endowment in production to achieve a payoff. For a player's production investment to be successful, it must meet or exceed a "production threshold". The game-theoretic analysis suggests that the ease with which production can be achieved plays a pivotal role in determining levels of aggression and the distribution of wealth: when thresholds are relatively low (high), there is a reduction (increase) in aggression and defense, with wealth distributions becoming less (more) unequal. Indeed, the behavioral experiment confirms that providing opportunities for economic production can reduce the intensity of attacker aggression and conflict. Both parties continue to invest in conflict with high frequency, and defenders' persistent need for defense constrains their ability to invest in production. As a result, wealth disparities increase in favor of attackers.

Chapter 4 investigates the dynamics of group cooperation and conflict under conditions of carrying-capacity stress. To sustain and support themselves and their members, groups need to cooperate on club goods to produce food, goods, or services (such as healthcare and education). Conversely, groups can also cooperate on aggressing and appropriating resources from other groups or, if targeted by such aggression, on defending themselves. Carrying capacity stress arises when a group's collective needs surpass available resources or when returns from shared resources become unpredictable. In Chapter 4, I examine if and how carrying-capacity stress in the form of uncertainty around the peaceful production of resources via a club good relates to the emergence of out-group aggression and intergroup conflict. Through an experimental model, participants in groups of three could contribute to a local club good or engage in conflict with another group. To manipulate carrying-capacity stress, the group benefit from club good provision was made to be either predictable or unpredictable. The results reveal that under unpredictable conditions, attackers reduce their contributions to the club good and increase their aggression towards out-groups. However, this aggressive strategy is not beneficial, as it leads to unsuccessful appropriation attempts and reduces earnings for both attackers and defenders. Overall, this chapter underscores the importance of stable, predictable returns from shared resources in preventing wasteful conflict and promoting overall welfare.

Overall, this dissertation makes a significant contribution to the existing literature on (asymmetric) conflict, helping to answer the question of how such conflict can be mitigated and how an attacking party can be dissuaded from aggression. Across three chapters, I find that 1) both attackers and defenders utilize peaceful alternatives for wealth generation when available, 2) this reduces conflict and attacker aggression, but does not fully eradicate it, 3) both parties benefit from the reduction of conflict, however, 4) due to the consistent costs associated with defending against the threat of attack, peaceful alternatives disproportionately benefit attackers rather than defenders.