Universidade do Minho
Escola de Psicologia

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Cooperation Under Uncertainty: A Dual-Process Approach

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A Dual-Process Approach
Daniela Cristina Ferreira da Costa
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Cooperation Under Uncertainty: A Dual-Process Approach

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Professor Doutor José Bernardo Bicudo de Azeredo Keating
e da
Professora Doutora Joana Rodrigues Arantes da Silva

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Statement of Integrity

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

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Cooperação em Situações de Incerteza: Abordagem Dualista do Processamento de Informação

Resumo

Diariamente, tomamos decisões cooperativas que afectam os outros e cujos resultados são frequentemente incertos. Investigações sugerem que, em situações de incerteza, os indivíduos tendem a reduzir a sua disposição para cooperar. Considerando que frequentemente as decisões são tomadas sob restrições de tempo, estudos tem vindo a explorar se os indivíduos cooperam espontaneamente ou se precisam de tempo. Neste sentido, investigadores que adotam modelos dualistas ao estudo da cooperação argumentam que a intuição favorece a cooperação em interações anónimas e numa única jogada, propondo a Hipótese da Heurística Social (HHS). Na presente tese, procuramos compreender como os processos cognitivos influenciam a cooperação em situações incertas através da manipulação da pressão do tempo. Foram realizadas quatro experiências, envolvendo a manipulação de limites temporais num Dilema dos Prisioneiros (DP) com uma ou várias jogadas, com e sem resultados estocásticos (Estudos 1 e 2), assim como uma decisão hipotética relacionada com a doença do coronavírus (COVID -19; Estudo 3). O primeiro estudo investigou um DP repetido com ou sem resultados estocásticos num contexto de perdas, com uma manipulação de restrição temporal. Posteriormente, realizou-se um segundo estudo para abordar as limitações do estudo anterior e aprofundar a investigação sobre os efeitos da HHS. Neste segundo estudo, foram realizadas duas experiências: na primeira, os participantes jogaram uma única vez, e na segunda, responderam a um jogo repetido. Os participantes jogaram um DP Determinístico ou Estocástico num contexto de perdas ou ganhos, sob condições de pressão temporal ou de espera. Após inferirmos o efeito da incerteza e da pressão do tempo num DP, no terceiro estudo investigamos se os efeitos encontrados eram específicos para dilemas sociais, aplicando um contexto de incerteza relacionado ao COVID-19. Neste estudo, os participantes avaliaram a probabilidade de ficarem em casa diante de diferentes situações hipotéticas relacionadas à ameaça de infecção por COVID-19, sob uma condição de restrição temporal. Os resultados desta tese sugerem que, sobre pressão do tempo, os participantes tendem a cooperar mais, mesmo num dilema social e numa doença infecciosa com um contexto relativamente incerto. Os dados revelam ainda que a incerteza nem sempre diminui a cooperação. Os resultados parecem apoiar a HHS, sugerindo que os indivíduos tendem a cooperar por default. Este trabalho analisa os efeitos da aprendizagem em jogos repetidos e contribui para o conhecimento dos fatores psicológicos e institucionais que promovem a cooperação.

Palavras-chave: cooperação, dilema dos prisioneiros, hipótese da heurística social, incerteza, pressão do tempo

Cooperation Under Uncertainty: A Dual-Process Approach

Abstract

In our daily lives, we often make cooperative decisions that may significantly impact others, and the outcome of these decisions is often uncertain. Previous research has suggested that individuals demonstrated a decreased willingness to cooperate under uncertainty. Additionally, these decisions are often made under time constraints. Recently, studies have explored whether individuals spontaneously cooperate with others or require time to make cooperative decisions. In line with this question, researchers applying the dual-process approach to cooperation have proposed the Social Heuristics Hypothesis (SHH), which argues that intuition favors cooperation in a one-shot anonymous interaction. In the present thesis, we aimed to investigate how cognitive processes influence cooperation in uncertain situations through the experimental manipulation of time pressure. Four studies were conducted involving the manipulation of time limits in both a one-shot and a repeated Prisoner's Dilemma (PD) game, with and without stochastic payoffs (Studies 1 and 2), as well as a hypothetical decision concerning the threat of the coronavirus disease (COVID-19; Study 3). Study 1 used a time-constraint manipulation to investigate a repeated PD game with or without stochastic payoffs in a loss frame. Study 2 addressed previous study limitations (including the lack of a forced time delay and the introduction of a comprehension task) and further investigated the effects of the SHH. To achieve this, in this study, two experiments were conducted: the first experiment, in which participants played a one-shot game, and the second experiment, in which they responded to a repeated game. Participants played either a Deterministic or a Stochastic PD in a loss or gain frame under time pressure or a forced time delay condition. After understanding the effects of uncertainty and time manipulation on the PD, Study 3 examined whether these effects were specific to social dilemmas by applying them to the COVID-19 uncertainty context. The study involved presenting participants with one of four hypothetical decisions related to the threat of COVID-19 infection. In the scenario presented, participants determined the likelihood of staying at home (prosocial intention) or going to work under pressure or in a time delay. Our results suggested that time pressure manipulation enhanced cooperative decision-making, even in a social dilemma and in a hypothetical infectious disease with a relatively uncertain context. In addition, we found that uncertainty does not always diminish cooperative behaviors. Our findings seem to support the SHH, suggesting that individuals, by default, tend to cooperate. The present work analyses learning effects in repeated games and advances the knowledge concerning the psychological and institutional that incentivize cooperative behaviors.

Keywords: cooperation, prisoner's dilemma game, social heuristics hypothesis, time pressure, uncertainty

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Abbreviations

SHH	Social Heuristics Hypothesis
COVID-19	Coronavirus Disease 2019
TFT	Tit-for-tat
PD	Prisoner's Dilemma
PGG	Public Goods Game
UG	Ultimatum Game
DG	Dictator Game
IDS	Interdepend Security
EV	Expected Value
EU	Expected Utility
SEU	Subjective Expected Utility
SPD	StochasticPrisoner's Dilemma
DPD	DeterministicPrisoner's Dilemma
PRL	Partial Reinforcement Learning
DE	Description-Experience
DI	Default-Interventionist
SCA	Self-Control Account
SVO	Social Value Orientation
SES	Socioeconomic Status
BART	Balloon Analogue Risk Task
BFI	Big Five Inventory
IRI	Interpersonal Reactivity Index
PT	Perspective Taking
EC	Empathic Concern
PD	Personal Discomfort
F	Fantasy
PANAS – SF	Short-form of the Positive and Negative Affect Schedule
β	Coefficient
SE	Standard Error
CI	Confidence Interval

OR	Odds ratio
LL	Lower Limit (as of a CI)
UL	Upper Limit (as of a CI)
AIC	Akaike Information Criterion
ANOVA	Analysis of Variance
TF2T	Tit for two Tats
OSF	Open Science Framework
GLMM	Generalized Linear Mixed Model
ARIMA	Autoregressive Integrated Moving Average
SARIMA	Seasonal ARIMA
RMSE	Root Mean Squared Error
BIC	Bayesian Information Criterion
WHO	World Health Organization
SARS	Severe Acute Respiratory Syndrome
H1N1	influenza A
OLR	Ordinal Logistic Regression
PCA	Principal Component Analysis
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
TLI	Tucker–Lewis Index
RMSEA	Root Mean Square Error of Approximation
WEIRD	Western, Educated, Industrialized, Rich, and Democratic

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Overview

As the title suggested, this doctoral thesis focuses on human cooperation and its importance in our daily life, since we are interested in understanding the mechanisms that promote and sustain cooperative decisions. In our daily lives, we frequently have to decide whether to cooperate with others or not. When individuals are presented with an opportunity to cooperate with others, such as when engaging in a joint research project, adopting protective measures during a pandemic, or adopting behaviors to mitigate climate change, they do not have complete certainty regarding the outcomes of their actions. In these cases, when making decisions, there usually is uncertainty concerning the actions of others and the overall outcome of the situation. As a result, individuals face a social dilemma where they should cooperate with others to address a problem, yet have the temptation to defect, doing nothing or even to free-ride on the efforts of others.

In addition to these uncertainties, in today's fast-paced world, individuals must make these decisions quickly and frequently without time to elaborate on complex information. For example, the majority of workplace decisions individuals make occur under time constraints. In this case, research has started questioning if individuals tend to cooperate spontaneously with others, or if time and processing capabilities are required to cooperate.

To provide a comprehensive understanding of these processes, we have developed the present doctoral thesis organized into five distinct chapters: an initial introductory theoretical chapter (Chapter 1), three chapters dedicated to the empirical studies developed (Chapters 2-4), and a final chapter corresponding to the general discussion, presenting the key findings and a reflection about the present work (Chapter 5).

The introductory chapter addresses the experimental and theoretical research developed on the study of cooperation and is divided into four major sections. In the first section of the introduction, we explore the challenge of cooperation and its importance, outlining the mechanisms that promote and sustain cooperation. In the second section, we will review the concept of cooperation within social dilemmas, focusing on the well-known case of the prisoner's dilemma. The third section of the introduction pays attention to the topic of cooperation under uncertainty and risk, which is one of the main topics of the present work. We start by briefly describing some of the theories developed within the field of judgment and decision-making under uncertainty. Then, we clarify the state-of-the-art concerning the impact of uncertainty and risk on the study of cooperation. The final section reviews the existing research on the cognitive foundations of cooperation. We begin by examining and summarizing the dual-process approach literature. Next, we explore the research developed on the cognitive foundations of cooperation and the

frameworks that have been proposed, with a particular emphasis on the Social Heuristic Hypothesis (SHH). At the end of the introductory chapter, we clarify the motivation for the present dissertation and provide a summary of each of the studies conducted throughout this project.

In the middle section of this dissertation, we present three chapters (Chapters 2-4), each representing the experimental studies developed. Specifically, in Chapter 2, we present the first empirical experiment conducted, followed by Chapter 3, in which we present Study 2, which consists of two experiments aimed at gaining a deeper understanding of the previously found effects. To conclude the middle section, in Chapter 4, we present Study 3, involving one practical application of the variables previously studied to the context of uncertainty regarding the Coronavirus Disease 2019 (COVID-19). Each empirical study presented in these chapters is self-contained, with its own literature review, methodology, results, and discussion.

The final chapter (Chapter 5) provides a general discussion that integrates the findings found in all studies developed. It also includes the presentation of the limitations and recommendations for future research, followed by a reflection on the overall implications of these findings and a brief conclusion. In addition, at the end of the dissertation, we include a chapter with supplementary materials for the empirical studies conducted.

CHAPTER 1

General Introduction

1. The Study of Cooperation

1.1. The Challenge of Cooperation

Individuals frequently engage in distinctive forms of prosocial behavior in their daily lives. Prosocial behavior describes actions that provide a benefit to others, such as cooperation (Hinde & Groebel, 1991). For example, individuals often make significant personal sacrifices to help their family members and friends. They may also donate blood, recycle, vote, tip, and contribute anonymously to charities (Henrich, 2018; van Lange et al., 2014). Another notable example of prosocial behavior is the outpouring of support in Portugal, where people have donated food, clothes, and money to aid those affected by wildfires in 2021. At the beginning of 2023, we observed numerous individuals donating to organizations aiding the rescue and recovery efforts following the recent earthquake in Turkey and Syria. In addition, we saw people offering to help others escape the conflict in Ukraine and provide shelter and food for war refugees. Furthermore, there are several examples in our daily lives of individuals contributing to public goods, such as promoting environmental sustainability (Dannenberg et al., 2015; van Lange et al., 2014).

Moreover, we can also encounter several examples of cooperative behaviors among animals (Davies et al., 2012). For example, several bird and mammal species produced alarm signals to alert other group members of the presence of a predator (Davies et al., 2012). Common vampire bats often regurgitate food and share it with roost-mates who cannot obtain a meal (Carter & Wilkinson, 2013; Wilkinson, 1988). Another example of cooperative behavior can be found in some breeding animals, such as meerkats, that, as an alternative to having their own offspring, they instead choose to help other group members reproduce (Davies et al., 2012). Furthermore, several species of animals, such as lions, join in groups for hunting (Davies et al., 2012).

However, despite these examples of cooperative behavior among humans and animals, evolutionary biologists have suggested that selfish behavior is prevalent and that natural selection has influenced individuals to act based on their own interests (Davies et al., 2012). According to the mechanism of natural selection, any traits or behaviors that decrease an individual reproductive success, also known as fitness, should not be selected over time (Barclay & van Vugt, 2015; van Lange et al., 2014). Individual reproductive success accounts for both direct and indirect fitness. Direct fitness considers the number of descendants carrying the same genes as the individual, while indirect fitness takes into consideration the reproductive success of relatives who share the same genes as the individual (Barclay & van Vugt, 2015; Davies et al., 2012; van Lange et al., 2014). Although evolution from a gene's

perspective can account for cooperation within relatives, cooperation among unrelated individuals is more complex (Dawkins, 2016; Jordan et al., 2015). Consequently, one question has emerged in the literature: What motivates individuals to engage in prosocial behavior and make personal sacrifices to help others if they are not related to them (Jordan et al., 2015)? Answering this question from the perspectives of natural selection and rational self-interest is difficult (Jordan et al., 2015).

The evolutionary theory considers a behavior cooperative if an individual action provides advantages for another individual (Bohn & Carter, 2021; Davies et al., 2012; West et al., 2007). Nevertheless, such behaviors are challenging since they could potentially diminish the relative fitness of the individual who exhibited that behavior (Hamilton, 1964; West et al., 2007). All altruistic and mutually beneficial behaviors are included in cooperation (Bohn & Carter, 2021; Davies et al., 2012). Choosing to cooperate gives the individual an immediate or delayed benefit that overweights the action's cost. As a result, cooperation is mutually beneficial and can be explained by self-interest behavior (Davies et al., 2012). However, altruistic behaviors do not benefit the actor and are more problematic to explain from an evolutionary perspective. Altruistic behavior benefits another person but is costly to the actor who engages in it (Davies et al., 2012).

Research in cooperative dilemmas has suggested that there is a conflict regarding what is suitable for the individual and what is suitable for the group (Rand & Nowak, 2013). The group does best if all individuals cooperate, but there is a temptation to defect and act in their self-interest (Nowak, 2006; Rand & Nowak, 2013; van Lange et al., 2013). In other words, cooperation (or prosocial) behaviors can be described as circumstances in which an individual incurs at a cost in order to benefit another individual or a group of individuals (Jordan et al., 2015; Rand & Nowak, 2013). The cost of a behavior can be identified as including time and effort, resources, and money (Jordan et al., 2015). Accordingly, cooperation can be advantageous in some situations we observe (since the cooperation costs are sometimes smaller than the benefits; Brown & Vincent, 2008; Jordan et al., 2015). Pairs or groups of individuals who can successfully cooperate with one another outperform those who cannot do so (Jordan et al., 2015; van Lange et al., 2014).

1.1.1. Mechanisms That Promote Cooperation

Over the years, researchers have attempted to answer several questions regarding cooperative behaviors, such as: How has cooperation evolved over time, and how can its evolution be explained? What motivates individuals to make sacrifices to assist others? (Jordan et al., 2015; Rand & Nowak, 2013). Previous studies in this field have suggested that for cooperation to occur, it is required a mechanism for

its evolution (Nowak, 2006; Rand & Nowak, 2013). A mechanism like this is an interaction pattern that favors cooperation over defection over time (Nowak, 2006; Rand & Nowak, 2013). In this section of the introduction, we will discuss the previously proposed explanations for the evolution of cooperation and mechanisms that promote cooperation (Nowak, 2006; Rand & Nowak, 2013; van Lange et al., 2014; West et al., 2007).

One of the most important and influential explanations for the evolutionary origins of cooperation is kin selection (Davies et al., 2012; van Lange et al., 2014; West et al., 2007). Kin selection occurs when cooperative behavior develops among individuals with similar genes (Rand & Nowak, 2013). The idea of conditional behavior, where an individual recognizes and acts differently toward kin than non-kin (kin discrimination), is the foundation of this explanation (Rand & Nowak, 2013). Moreover, kin selection is associated with inclusive fitness theories, a mathematical approach to consider fitness effects (Rand & Nowak, 2013; West et al., 2007). The inclusive fitness theory developed by Hamilton (1964) demonstrated how altruistic cooperation can be preferred among kin (Davies et al., 2012; West et al., 2007). Likewise, inclusive fitness combines direct and indirect fitness effects (van Lange et al., 2014). This idea is formalized by Hamilton's rule ($rb - c > 0$), which claims that a trait will be favored by natural selection if the advantages for the recipient (b), weighted by the genetic affiliation between both the recipient and the actor (r), overcomes the costs to the actor (c) of the action (Davies et al., 2012; West et al., 2007).

Another mechanism for the evolution of cooperation is direct reciprocity, which occurs once individuals frequently interact and align their behaviors based on each other's cooperative actions (Jordan et al., 2015; Rand & Novack, 2013). This explanation is based on the theory of reciprocal altruism (Trivers, 1971; van Lange et al., 2014). The reciprocal altruism theory assumes that when individuals help each other, they frequently receive compensation later (Trivers, 1971; van Lange et al., 2014). Reciprocity is the foundation of one evolved strategy in which individuals favor helping those who have helped them in the past (Trivers, 1971; van Lange et al., 2014). A well-known strategy for direct reciprocity is "Tit-for-tat" (TFT), where a player initially cooperates and then repeats the other player's previous action. However, errors can occur in daily interactions, and individuals may replace former strategies with more forgiving choices (Jordan et al., 2015; Rand & Nowak, 2013). For example, they may choose to cooperate despite the others having defected (Jordan et al., 2015; Rand & Nowak, 2013). Cooperation can emerge through game repetition, but if the likelihood of future interaction is low or the reward for defecting is high, people will learn to defect (Jordan et al., 2015).

As mentioned, prosocial behaviors are presumed to happen among relatives and by expecting direct reciprocation, but they are not limited to these mechanisms (van Lange et al.,2014). Another mechanism for explaining the evolution of cooperation is indirect reciprocity, which states that when an individual engages in cooperative behavior, the reciprocation can come from someone other than the direct recipient of the act (Nowak & Sigmund, 2005). In other words, an individual behavior toward another can be influenced based on the latter's past behavior toward others (Jordan et al., 2015). Therefore, individuals who help others develop a favorable reputation, which increases their chances of receiving help in the future when needed (van Lange et al.,2014). Conversely, individuals with a poor reputation due to frequently refusing to help others are less likely to receive help for themselves (van Lange et al.,2014). The presence of third-party observers and the spread of positive information regarding previous interactions between individuals enhance cooperative behavior (Rand & Novack, 2013). Indirect reciprocity is facilitated by social norms that update reputations based on interactions between individuals and dictate whether to cooperate based on the existing knowledge about the other individual (Jordan et al., 2015; Rand & Nowak, 2013). In experiments, while playing economic games, individuals exhibited greater cooperation when they received feedback (i.e., when others were aware of their actions), demonstrating the importance of reputation (Jordan et al., 2015; van Lange et al., 2014). Even subtle cues, such as depictions of eyespots ("*the eyes effect*"), can increase prosocial behavior due to the strong influence of reputation (Jordan et al., 2015; Sparks & Barclay, 2013). Compared to kin selection or direct reciprocity, indirect reciprocity may justify cooperation on a larger scale (Jordan et al., 2015; van Lange et al., 2014). Several other methods of enforcing cooperation were described in the literature (e.g., punishment and sanctions; Davies et al., 2012). Enforcement refers to the mechanism of rewarding cooperators and punishing free riders, which reduces self-interest behaviors (Davies et al., 2012; West et al., 2007). Enforcement mechanisms such as institutions, policing, and sanctions are essential for preserving cooperation in large groups (Jordan et al., 2015; West et al., 2007).

Two other mechanisms relevant in the literature for the evolution of cooperation are spatial selection and multilevel selection (Nowak, 2006; Rand & Nowak, 2013). Spatial selection is based on individuals' physical distribution and group interactions (Nowak, 2006; Nowak et al., 2010; Rand & Nowak, 2013). When the spatial structure is available, it can create opportunities for cooperation to succeed (Nowak et al., 2010; Riolo et al., 2001). The existence of a spatial structure allows cooperative individuals to form groups and interact more frequently (Rand & Nowak, 2013). In this case, cooperative individuals may benefit more from clustering than non-cooperative individuals (Rand & Nowak, 2013). The other mechanism for the evolution of cooperation identified by the literature is the multilevel selection.

This mechanism considers how competition and cooperation interact within and between groups of individuals (Rand & Nowak, 2013; Traulsen & Nowak, 2006). According to this mechanism, cooperative behavior can still develop even if individual selection favors defection as long as it helps the group and allows it to outcompete rival groups (Rand & Nowak, 2013). If cooperative groups outperform non-cooperative ones, selection can act at the group level, favoring the increase of cooperative traits (Rand & Nowak, 2013; Traulsen & Nowak, 2006).

Rand and Nowak (2013) have introduced a distinction between social behaviors and mechanisms that promote the evolution of cooperation. The authors stated that while social preferences are essential to understand why individuals choose to cooperate, they did not directly give an explanation of how cooperation has evolved (Rand & Nowak, 2013). The prevalence of social preferences among humans is expected to have provided evolutionary gains, as cooperation has been typically advantageous to an individual's long-term survival (Everett et al., 2015). Empirical evidence has demonstrated that participants in economic games are concerned not only with their own outcomes but also with the outcomes of others (Camerer, 2003a). In this sense, social preferences refer to a concern for the well-being or interests of others (i.e., "other-regarding preferences"; Fehr & Fischbacher, 2005). These preferences are influenced by the concern to maintain positive relationships with others, conform to social norms, and promote cooperation and fairness (Bowles & Gintis, 2011). Social preferences incorporate a range of psychological mechanisms that influence individuals' behavior, such as generalized reciprocity, strong reciprocity, ingroup bias, inequity aversion, social efficiency, and a Rawlsian motive to cooperate (Everett et al., 2015; Fehr & Fischbacher, 2005; Fehr et al., 2002; Fehr & Schmidt, 1999; Rand & Nowak, 2013). Generalized reciprocity is the idea that someone who recently had help is also expected to support others (Rand & Nowak, 2013). Strong reciprocity describes individuals with a disposition to reward cooperative behaviors and punish selfish actions (Fehr & Fischbacher, 2005; Fehr et al., 2002; Rand & Nowak, 2013). Ingroup bias refers to the act of favoring members of one's group over those from other groups (Everett et al., 2015; Rand & Nowak, 2013). Regarding inequity aversion, it refers to an individual strong preference to adhere to equal outcomes, and their objective is to minimize the differences in payoffs among the group (Bolton & Ockenfels, 2000; Fehr & Fischbacher, 2005; Fehr & Schmidt, 1999). When confronted with unequal payoffs, individuals experience a negative utility; they care about the equal allocation of outcomes/resources across all participants as an alternative to only considering their own (Bolton & Ockenfels, 2000; Fehr & Schmidt, 1999). Additionally, individuals often demonstrate a utilitarian concern for social efficiency, seeking to maximize the total payoff of all participants (Capraro et al., 2017; Fehr et al., 2006). Instead of focusing on the distribution of payoffs, their utility is obtained

after a concern for the total group outcomes (Capraro et al., 2017; Charness & Rabin, 2002).). Research has also demonstrated that individuals revealed a Rawlsian motive for helping others, implying that they are concerned about helping those considered the most disadvantaged (Capraro et al., 2017; Fehr et al., 2006). The main aim of this motivation is to maximize the payoff of the group's least advantaged individuals (Capraro et al., 2017; Charness & Rabin, 2002).

Despite the temptation to act for selfish reasons, human society has a history of working together with unknown individuals (Jordan et al., 2015). As reviewed, several mechanisms influence cooperative behaviors, and it is essential to consider how these mechanisms interact and explain human cooperation (Rand & Novack, 2013). Theoretical work through evolutionary game theory provides insights into the conditions that give rise to cooperation (Rand & Nowak, 2013). Evolutionary game theory combines concepts of game theory and evolutionary dynamics and examines the development of strategies in a population of interacting individuals (Rand & Nowak, 2013). The work on evolutionary game theory is complemented by experimental work that uses social dilemmas to further investigate how cooperation among individuals occurs and is maintained (Camerer, 2003a; Jordan et al., 2015). Furthermore, experimental research regarding the mechanisms that promote cooperation will contribute to a further understanding of human cooperation and help us encourage cooperation within our society (Jordan et al., 2015).

1.2. Measures of Cooperation: The Study of Social Dilemmas

Cooperation and self-interested motives were primarily studied using social dilemmas (Kollock, 1998; Rand & Nowak, 2013; van Lange et al., 2014; van Lange et al., 2013). Many of the world's most challenging issues can be modeled by social dilemmas that address our ability and motivation to cooperate (van Lange et al., 2014). Dawes (1980) initially defined social dilemmas as situations with two essential attributes. First, there exists a dominant strategy involving defection, where individuals receive a higher payoff if they choose to defect than if they choose to cooperate, independently of what the others choose (e.g., using all the available energy; van Lange et al., 2014). Second, all individuals will get a lower payoff if they all choose to defect rather than cooperate.

However, researchers have noticed that this definition does not clearly explain other outcome structures (i.e., interdependence structures) that demonstrate the conflict between self-interests and collective benefits (van Lange et al., 2013). In social dilemmas, an outcome or interdependence structure is often described as a situation in which an individual's final payoff is dependent on the decisions of the others in the group (van Lange et al., 2013). In the study conducted by van Lange et al.(2013), the

authors argue that Dawes's (1980) definition only considers the outcome structure of a Prisoner's Dilemma (PD) game (van Lange et al., 2014; van Lange et al., 2013). The authors referred that the previous definition does not account for the temporal or time dimensions, and in social dilemmas, the consequences of an action can be immediate or delayed (van Lange et al., 2014; van Lange & Joireman, 2010; van Lange et al., 2013). Considering this, van Lange and colleagues (2013) defined social dilemmas as interdependence structures opposing immediate self-interest and long-term collective interest. In other words, social dilemmas are situations in which a non-cooperative behavior can sometimes be appealing since it can have higher payoffs (often short time; van Lange et al., 2013). In addition, if all individuals decide not to cooperate, eventually, all end up with a lower payoff or in a worse position (often in the long term) than if they all had decided to cooperate (van Lange et al., 2014; van Lange et al., 2013). For example, we may choose to drive our car to work since it is more convenient than other forms of transportation, and in this case, there is an immediate self-benefit. However, this behavior might contribute to long-term negative environmental consequences, such as air pollution (van Lange et al., 2013). Another example could be observed during COVID-19 when an individual decided to attend a large gathering, such as a party (immediate self-benefit), despite the increased risk of contracting the virus, contributing to long-term negative consequences for the population.

Social dilemmas are considered challenging because behaving in one's immediate self-interest is appealing, although all individuals benefit from acting in consideration of the long-term collective benefit (van Lange et al., 2014). For example, everyone would benefit from a better environment, yet it requires individual immediate costs such as saving energy or restricting water consumption during a dry season (van Lange et al.,2014). Several examples in our daily lives can be represented in a social dilemma structure, such as the overuse of natural resources and the increase of greenhouse gases (van Lange et al., 2014). Additionally, several forms of intergroup conflicts share features with social dilemmas, such as the Middle East conflict and the conflict between Russia and Ukraine(van Lange et al., 2014). After all, group members would rather have peace than war, since having peace meets a critical need for security. The social dilemma literature has a game theory conceptual background (van Lange et al., 2014; van Lange et al., 2013). Researchers have used game theoretical models to develop experimental frameworks where individuals have to make decisions impacting their own and other participants' outcomes, modulating real-life settings (Camerer, 2003b; Jordan et al., 2015; Rand & Nowak, 2013). The PD and the Public Goods Game (PGG) are two of the most popular paradigms used to explore cooperative behavior (Jordan et al., 2015; van Lange et al., 2014).

The social dilemmas literature also distinguishes between take-some and give-some dilemmas (McCarter et al., 2011; van Lange et al., 2014). Research in give-some dilemmas revealed that all individuals might benefit from a good or resource regardless of whether they have contributed to the public good or not (Fehr & Gächter, 2002; Fischbacher et al., 2001; van Lange et al., 2014). The PGG is frequently used as a paradigm for exploring give-some dilemmas (McCarter et al., 2011; van Lange et al., 2014). To illustrate this type of dilemma, we might think of a global agreement to reduce the global dependency on fossil fuels by promoting the use of clean energy (Dannenberg et al., 2015; van Lange et al., 2014). Several countries can make an effort to increase the use of clean energy through cooperation, resulting in a cleaner environment. However, others may choose not to contribute to these efforts yet still can benefit from the efforts made by others. Regarding take-some dilemmas, individuals may have to decide whether and how much to consume from a shared resource to which all group members have unrestricted access (van Dijk et al., 2004). The commons/resource dilemma is a typical example of a take-some dilemma (McCarter et al., 2011; van Dijk et al., 2004; van Lange et al., 2014). To illustrate this type of dilemma, we might think about the overexploitation of resources (van Dijk et al., 2004). The development of the take-some games was primarily influenced by the work of Hardin (1968) on the tragedy of the commons.

1.2.1. The Prisoner's Dilemma Game

One of the difficulties in achieving cooperation is that individuals who choose to free-ride may take advantage of others' cooperative behavior (Davies et al., 2012). In this case, free riders could take advantage of the cooperative behaviors of others while avoiding the costs of cooperation (Davies et al., 2012). The PD game has been commonly utilized to demonstrate this scenario, offering a helpful model to illustrate the problems of achieving cooperation in animal and human societies (Axelrod & Hamilton, 1981; Davies et al., 2012; van Lange et al., 2014).

Imagine a game between two strategies, C (cooperate) and D (defect), where the payoffs to players A and B for each possible pair of moves are shown in Table 1. Table 1 demonstrates the payoff matrix for this game with some illustrative values. For instance, consider player A, who finds another individual (player B) who always cooperates (van Lange et al., 2014). If player A also cooperates, they both receive a reward of five. Whereas if player A defects, the player will receive a payment of seven, and player B, who chooses to cooperate, receives nothing. In this case, when player B cooperates, it pays off for player A to defect (van Lange et al., 2014). Now, suppose player A discovers that B always defects. In this case, if player A chooses to cooperate, the player will gain nothing, and player B will receive a

compensation of seven. In contrast, if player A also decides to defect, both players get a compensation of three. Thus, if player B defects, it is beneficial to player A to also defect (van Lange et al., 2014).

The letter symbols represented in Table 1 correspond to the payoffs: R stands for the *"reward"* payoff if both choose to cooperate, P is the "*punishment*" received if both defect, T corresponds to the "*temptation*" that one individual receives if only that player chooses to defect and the other player chooses to cooperate, and S stands for the "*sucker's payoff*" that one individual received if only that player chooses to cooperate and the other player chooses to defect (Rand & Nowak, 2013; Rapoport & Chammah, 1965). In this game, both players earn more if they cooperate than if they both defect, but the highest payoff is earned by a defector whose partner cooperates (Dal Bó & Fréchette, 2018; Rand & Nowak, 2013). Concluding, choosing to defect is the optimal individual choice despite the other partner's decision, but choosing to cooperate is the optimal choice from a group perspective (Axelrod & Hamilton, 1981; Dal Bó & Fréchette, 2018; Rand & Nowak, 2013). In the example above, the game is symmetric (i.e., the payoffs are the same for both players; van Lange et al., 2014).

Table 1

Example of a Payoff Matrix From the Prisoner's Dilemma Game

		Player B	
		Cooperate	Defect
Player A	Cooperate	R= 5 R= 5	T= 7 S= 0
	Defect	S= 0 T= 7	P= 3 P= 3

The classical exemplification of the PD game introduced by Albert W. Tucker suggested that the matrix presented in Table 1 was equivalent to a situation where two individuals are imprisoned and accused of committing a crime together (Rapoport, 1989; van Lange et al., 2014). The two prisoners are imprisoned separately, and the police encourage each to implicate the other. Since there is no communication between the two individuals, coordination of choices is difficult; in this case, each individual has to infer what the other will do (van Lange et al., 2014). The authorities offer each prisoner a deal: if one prisoner remains silent (cooperates) while the other confesses (defects) and implicates their partner, the cooperating prisoner will receive a sentence while the defecting prisoner will go free

(Rapoport, 1989; van Lange et al., 2014). If both prisoners remain silent, they will both receive a moderate sentence. However, if both prisoners confess, they will both receive a harsher sentence.

In game theory, an evolutionarily stable strategy is a strategy or behavior that, once established in a population, is difficult to be surpassed by alternative strategies; that is, one mutant individual with a different strategy from the population does not gain an advantage (Dawkins, 1980). The concept of the evolutionarily stable strategy in game theory is an improvement on the Nash Equilibrium (Iqbal & Toor, 2001). John Nash developed the concept of the Nash Equilibrium, and it describes a situation in a game where players choose strategies that best respond to each other's strategies, and no player could gain an advantage by changing their strategy (Camerer, 2003a). In other words, each player selects a strategy that maximizes their own payoff, considering the strategies chosen by all other players. In the context of a game such as the PD presented in Table 1, mutual defection is the only Nash equilibrium in this scenario. However, it is essential to note that mutual cooperation would result in higher payoffs for both players, making mutual defection a suboptimal outcome for both players (Camerer, 2003a). In a one-shot game, the Nash equilibrium is to {defect, defect}, and it is also the Subgame Perfect Nash equilibrium of the finitely repeated game when there is a known end to the game (Angelova et al., 2013; Friedman & Oprea, 2012).

The conditions for this conclusion to hold in the payoff matrix and be defined as a prisoner's dilemma game are $T > R > P > S$ and $2R > T + S$ (Axelrod & Hamilton, 1981; Dal Bó & Fréchette, 2018; Davies et al., 2012; van Lange et al., 2014). This latter condition is needed for a repeated game, so effortless alternation between cooperating and defection is less beneficial over the long run than repeated mutual cooperation (Dal Bó & Fréchette, 2018; van Lange et al., 2014). Moreover, the values in a payoff matrix can be used to determine how cooperative or tempted an individual is (van Lange et al., 2014). Rapoport (1967) introduced the K index to compute the degree of cooperativeness or temptation. The value of K is estimated as $K= (R-P)/(T-S)$. It varies from 0 to 1.00, with greater values (close to 1.00) reflecting greater cooperativeness and smaller values (close to 0) a more significant amount of defection. If the value of K is high, the explanation is that there is not a great benefit of engaging in temptation, while the contrary happens if K is small, indicating that temptation will be more attractive. Therefore, if everything else remains the same, it is assumed that the likelihood of cooperation will increase as the K index increases (van Lange et al., 2014).

Several other games have been developed that help study other social motives in strategic interactions (Camerer, 2003a, 2003b). Some of these games involve rearrangement of the payoff values that correspond to the temptation, reward, sucker, and punishment or alternation in how choices are

made (van Lange et al., 2014). Two examples are the Chicken Game (where the values of punishment and the sucker are changed) and the Stag Hunt Game (where the values of temptation and reward are exchanged; van Lange et al., 2014). There are also other experimental games where the nature of the game is modified, with the most common games being the Ultimatum Game (UG), Dictator Game (DG), and the Trust Game (for a review, see Chapter 2 of Camerer, 2003a). These games provide insights into social norms, fairness, altruism, and trust in economic situations.

Further adaptations of the PD and other social dilemmas have been made to explore further societal problems that involve risk and uncertainty. One example is the Interdepend Security Games (IDS; Heal & Kunreuther, 2005; Kunreuther et al., 2009; Kunreuther & Heal, 2003) and other adaptations of social dilemmas, where the outcome is determined not just by individual decisions but additionally by outcome uncertainty (Bendor, 1993; Bereby-Meyer & Roth, 2006; Kunreuther et al., 2009).

1.3. Cooperation Under Uncertainty and Risk

1.3.1. Judgment and Decision-Making Under Uncertainty

Theories of decision-making under uncertainty focus on the study of decisions regarding uncertain outcomes (Fishburn, 1988). The decisions made under uncertainty may be distinguished into decisions under risk, which refers to a condition that occurs with well-specified probabilities (e.g., gambling decisions; Bernoulli, 1738/1954; Ellsberg, 1961; Fishburn, 1988; Knight, 1921) and decisions under ambiguity, where probabilities are unknown (Ellsberg, 1961; Vives & FeldmanHall, 2018). For example, cooperative decisions are usually made under uncertainty in which multiple possible future states exist. In many situations, when individuals decide to cooperate, they deal with incomplete information and do not know the outcome of the cost of deciding to cooperate. In addition, individuals typically have to make decisions without knowing whether others have decided to cooperate or not. These situations create uncertainty and make determining the best course of action difficult.

The decision-making field received much attention from many disciplines and can be studied using several theoretical approaches (Baron, 2014; Johnson & Busemeyer, 2010). For example, some researchers are curious about how individuals make the optimal decision within certain circumstances (Johnson & Busemeyer, 2010). The normative approach uses mathematical optimization to find the optimal decision for a given situation (Johnson & Busemeyer, 2010). However, individuals generally make 'suboptimal' decisions contrary to the expectations of the normative perspective (Johnson & Busemeyer, 2010). Moreover, according to descriptive theories, it is unlikely that individuals will be able to use the analytical tools created following normative guidelines. The descriptive perspective aims to understand

how individuals make decisions by considering psychological factors that influence decision-making (Johnson & Busemeyer, 2010). In order to better clarify the literature on judgment and decision-making, in the next section, we will review some concepts of the normative, descriptive, and prescriptive models, which can be classified based on the underlying behaviors and goals of the decisions (Baron, 2012, 2014). However, in this dissertation, we will be given little attention to the prescriptive theory.

1.3.1.1. Normative Theories. Normative decision theory analyzes how individuals make the right decision (Fishburn, 1988; Peterson, 2009). These theories focus on developing and justifying principles for assessing and selecting between different options (Fishburn, 1988). These principles are presented as rules that individuals should adhere to or may desire to adhere to (Fishburn, 1988). Every day, we make several decisions under conditions of uncertainty. For example, we might choose to donate to a charity, which may result in helping the ones who need it, or our donation may not reach the most vulnerable.

Expected value (EV) was the foundation of economic theories and the precursor of utility value (Bernoulli, 1738/1954; Johnson & Busemeyer, 2010). It refers to the average outcome of a decision or a gamble, considering all possible outcomes and their probabilities. The expected value of an option EV(X) is determined by multiplying each variable value by its corresponding probability and then adding each of the multiplication products (Johnson & Busemeyer, 2010). The mathematical rule is then to choose the alternative that has the highest expected value:

$$\mathrm{EV(X)} = \sum_{i=1}^{n} p_i x_i \quad (1)$$

In formula (1), x_i represents each possible outcome of a variable, and p_i represents the probability associated with each outcome (Johnson & Busemeyer, 2010). For example, imagine a situation (initially formulated by Maurice Allais) where participants can decide between two options. If the participants choose the first option, they will, with certainty, gain 1 million euros. However, if the participants choose the second option, they have an 89% chance of gaining 1 million euros, a 10% chance of gaining 5 million, and a 1% chance of receiving nothing (Johnson & Busemeyer, 2010; Slovic & Tversky, 1974). In this case, following the calculation of the EV, it suggests that participants should choose the second option since EV(2)= 1.39 million > EV(1)= 1 million. Therefore, the EV is helpful for decision-making because it allows individuals to compare options and choose the highest expected value (Johnson & Busemeyer, 2010).

However, when studying the dynamics of the St. Petersburg paradox, Bernoulli (1738/1954) observed that an individual's subjective utility or worth of a payoff is not always directly associated with

the payoff's absolute or expected value (Peterson, 2009; Pleskac et al., 2015). Instead, factors such as the likelihood of winning can affect how much value an individual attributes to an outcome (Peterson, 2009). For example, in the St. Petersburg Paradox, individuals can pay a certain amount of money to flip a coin, with the chance of receiving a significant payoff if the coin lands head (Bernoulli, 1738/1954; Peterson, 2009; Pleskac et al., 2015). Each time the coin is flipped and lands on heads, the individual's prize money doubles. However, the game ends when the coin lands tails (Peterson, 2009). Then, the total amount of the prize is calculated, and each player is paid a sum equivalent to 2^n, where n represents the number of times the coin has been flipped (Bernoulli, 1738/1954; Peterson, 2009; Pleskac et al., 2015). Following the calculation of formula 1, the EV of this gamble is infinite (Pleskac et al., 2015). Based on the expected value theory, individuals would be willing to pay any finite amount to play the game. Yet, despite the infinite expected value, most individuals would not be willing to pay a large amount of money to play the game (Peterson, 2009).

Given the example above, between options 1 and 2, although option 1 has a lower expected value, most experimental participants choose it when given a chance to choose between the two alternatives (Johnson & Busemeyer, 2010). Therefore, it is suggested that individuals do not objectively assess (monetary) results but do so subjectively (Johnson & Busemeyer, 2010). A middle-class individual and a billionaire put different subjective values on the same amount of money. For example, a middle-class individual will attribute more subjective worth to 1,000 euros than a billionaire (e.g., Cristiano Ronaldo; Johnson & Busemeyer, 2010); as an individual gets richer, every successive dollar is less valuable than the last. The diminishing marginal utility describes this phenomenon where, as the initial objective value or utility grows, the corresponding gains in subjective value decrease (Johnson & Busemeyer, 2010).

These developments from the previous notion of EV conducted by Bernoulli (1738/1954) led to the development of the expected utility (EU) theory (Pleskac et al., 2015; Stanovich, 2016). As a result, the calculation of EU requires a similar calculation to EV, except that this entails a function (see formula 2) that converts the objective value into subjective utility, U(X) (Johnson & Busemeyer, 2010). Then, this simple modification suggests selecting the alternative with the highest expected utility (Bernoulli, 1738/1954) EU(X):

$$\mathrm{EU(X)} = \sum_{i=1}^{n} p_i U(x_i) \quad (2)$$

Critics of the EU theory led to the work developed by von Neumann and Morgenstern (1944) that surpassed previous limitations and provided an axiomatic basis for the EU theory (Johnson & Busemeyer,

2010; Pleskac et al., 2015). The logic axioms in the EU are a set of principles or prepositions used to identify how individuals should make choices when faced with uncertain outcomes (Peterson, 2009; Pleskac et al., 2015). Later, Savage (1954) also extended the prior knowledge of von Neumann and Morgenstern's (1944) axiomatic framework beyond subjective utility to incorporate subjective probability for uncertain events with unknown probabilities (i.e., ambiguous events; Johnson & Busemeyer, 2010; Pleskac et al., 2015). Subjective Expected Utility (SEU) theory is an extension of the EU theory, which considers that an individual's beliefs about probabilities may be subjective and uncertain (Johnson & Busemeyer, 2010). Several axioms have been proposed, particularly from work developed by von Neumann and Morgenstern as well as Savage (for a review, see MacCrimmon and Larsson, 1979), such as independence axioms (e.g., sure-thing principle; Pleskac et al., 2015).

The SEU formula can be represented as follows for a set of n possible outcomes:

$$\mathrm{SEU(X)} = \sum_{i=1}^{n} \pi_i U(x_i) \quad (3)$$

In formula 3, π_i represents the product of the individual's subjective probability, and U(x_i) represents the subjective utility associated with that outcome. SEU theory posits that individuals make choices that maximize their subjective expected utility, which is the product of the individual's subjective probability of each outcome (π_i) and the utility that the individual attaches to that outcome (Johnson & Busemeyer, 2010). The axioms are fundamental to almost any rational decision-making. Nevertheless, individuals demonstrate systematic violations when making decisions (Johnson & Busemeyer, 2010), as shown, for example, by the Allais and Ellsberg Paradoxes (Peterson, 2009). Both paradoxes appear to violate the sure-thing principle (Peterson, 2009). These paradoxes demonstrate people's contradictory preferences for uncertain events, which emerge either based on the desire to escape uncertainty concerning outcomes, such as in the Allais Paradox, or as in the case of the Ellsberg paradox, from the desire to avoid epistemic uncertainty (i.e., when it is due to lack of knowledge) regarding probabilities (Peterson, 2009). The discrepancy between expected utility theory predictions and actual human behavior led researchers to search for alternative explanations (Johnson & Busemeyer, 2010). As a result, theories began to diverge significantly from "rational" views to account for humans' "irrational" decisions.

1.3.1.2. Descriptive Theories. Unlike the previous theory, descriptive decision theory focuses on what will occur in a situation, not what should (Johnson & Busemeyer, 2010). The descriptive theory takes into account external factors that impact an individual decision toward less-than-optimal outcomes (Johnson & Busemeyer, 2010). Descriptive theories in decision-making are more interested in explaining

individuals' decisions than in providing a logical foundation for deciding as EV, EU, and SEU (Johnson & Busemeyer, 2010).

Cognitive psychologists have identified many gaps between descriptive and normative models of human behavior (Stanovich, 1999). For instance, individuals frequently misinterpret probabilities, exhibit confirmation bias, violate the axioms of choice, and exhibit many other cognitive processing biases (Stanovich, 1999; Stanovich & West, 2000). Indeed, describing how human behavior diverges from normative models is the principal objective of the heuristics and biases literature (e.g., Kahneman et al., 1982; Tversky & Kahneman, 1974). Additionally, several theories, such as the Prospect Theory introduced by Kahneman and Tversky (1979), have argued that the expected utility theory is inadequate to explain choices made under uncertainty.

1.3.1.2.1. Heuristics and Biases. At the beginning of the 1970s, Tversky and Kahneman developed the heuristics and biases program (Raue & Scholl, 2018; Tversky & Kahneman, 1974). A heuristic is a quick decision-making method, a mental shortcut, that enables judgments to be made without considering all the information at hand and is helpful when there is not enough time or cognitive ability for careful deliberation (Raue & Scholl, 2018; Stanovich, 2016). The heuristics and biases program investigates the cognitive mechanisms behind an individual's judgment and decision-making. It focuses its research on recognizing systematic errors (biases), which then leads to identifying heuristics (Kahneman & Frederick, 2002; Raue & Scholl, 2018; Stanovich, 2016). Kahneman and Tversky (Kahneman & Tversky, 1972; Tversky & Kahneman, 1974) found that in certain situations, individuals systematically make decisions that do not follow the rules of probability, specifically the Bayes theorem, but instead use heuristics to make decisions (Kahneman & Frederick, 2002). These authors (Kahneman et al., 1982; Kahneman & Tversky, 1972; Tversky & Kahneman, 1973, 1974) described three main heuristics: representativeness, availability, and anchoring and adjustment (Gilovich & Griffin, 2002).

The representativeness heuristic is applied when individuals tend to determine the probability of a situation or the characteristics of a person according to the similarity to a stereotype (Tversky & Kahneman, 1974). To clarify, Tversky and Kahneman (1974) suggested that individuals estimate the probability or frequency of an event based on how representative it is of a particular category rather than according to the actual base rate or prior probability of the event (Raue & Scholl, 2018; Tversky & Kahneman, 1974). Some associated biases of the representativeness heuristic are conjunction errors and the insensitivity to base-rate frequency (Tversky & Kahneman, 2002). The Linda problem is one of the classic examples, where individuals compared the probability that a person named Linda is a feminist and a bank teller or only a bank teller based on a description of her characteristics (Kahneman & Tversky,

1982). In this scenario, participants tend to overestimate the probability that both events coinciding (Linda as a bank teller plus being a feminist) as greater relative to the likelihood of occurring alone (Linda as a bank teller). This judgment corresponds to a violation of the rules of probabilities, where individuals believe that the conjunction of two events is more likely to occur than a single event, which is called the conjunction fallacy (Kahneman & Tversky, 1982; Raue & Scholl, 2018; Tversky & Kahneman, 2002). Another potential bias is the base-rate fallacy, which refers to the underlying probability of an event occurring within a specific population; for instance, the probability of specific characteristics in a given population (Raue & Scholl, 2018; Tversky & Kahneman, 1974). Since Linda's description closely resembles the typical profile of a feminist, it may appear probable that she is a feminist (Raue & Scholl, 2018). Research has suggested that relying on the representativeness heuristic may lead to correct estimations since representativeness and the likelihood of belonging to a group are often related (Raue & Scholl, 2018).

The availability heuristic refers to the propensity to estimate the probability of an event based on how often examples are recalled (Schwarz & Vaughn, 2002; Tversky & Kahneman, 1973, 1974). Individuals tend to overrate the likelihood of events that are more quickly accessible in their memory, and this bias can lead to decision-making errors (Tversky & Kahneman, 1974). For instance, Tversky and Kahneman (1973), in their study 8, conducted an experiment to test this heuristic with names of entertainers and public figures in which they manipulated the fame status and the distribution of gender. In two of the lists (one for public figures and one for entertainers), more names of women (n = 20) than men (n = 19) were presented, and men's names were more famous than women's names. The two other lists consisted of the opposite manipulation. Participants were asked to recall the names and estimate if more women or men were on each list. Results revealed that the majority of participants were incorrect since they reported that the more famous names were more frequent (Tversky & Kahneman, 1973). The reliance on the availability heuristic explained this finding; that is, since participants were able to recall famous names easier, they overestimated the related category (Raue & Scholl, 2018).

The Anchoring and Adjustment Heuristic refers to the tendency for individuals to rely on an initial value or starting point when making judgments or decisions (Tversky & Kahneman, 1974). Anchors can lead to biased judgments despite being relevant or irrelevant to the task (Chapman & Johnson, 2002; Raue & Scholl, 2018). In a mathematical task, the order of numbers can act as a relevant anchor for the task. For example, when asked to estimate the product of two sequences: i) 1*2*3*4*5*6*7*8 and ii) 8*7*6*5*4*3*2*1, participants made lower estimations for the first sequence than for the second one. This result can be justified because individuals frequently estimate according to the first pair of numbers

they saw rather than doing the calculation (Chapman & Johnson, 2002; Raue & Scholl, 2018; Tversky & Kahneman, 1974). In another experiment with irrelevant anchors, individuals had to estimate the proportion of African states within the United Nations after the anchor presentation (Chapman & Johnson, 2002; Raue & Scholl, 2018; Tversky & Kahneman, 1974). Before starting this task, a manipulated fortune wheel displayed either the number 10 or the number 65 before they made their estimations. Subsequently, participants were asked to determine if the number of African states was greater or smaller than the displayed number (10 or 65), which served as an anchor for their judgments and later to estimate the value by moving up or down from the provided number (Raue & Scholl, 2018; Tversky & Kahneman, 1974). Results revealed that groups that received a higher number from the wheel of fortune provided more accurate estimates than groups that received smaller numbers (Chapman & Johnson, 2002). These results demonstrated that irrelevant anchors influenced people's judgments (Chapman & Johnson, 2002; Raue & Scholl, 2018; Tversky & Kahneman, 1974).

The three heuristics presented were part of Tversky and Kahneman's heuristics and biases program and have gained significant notoriety in recent years (Raue & Scholl, 2018). In addition, this approach to heuristics led to the development of many more heuristics by Kahneman, Tversky, and many other researchers (for a review, see Gilovich et al., 2002; Kahneman et al., 1982).

1.3.1.2.2. Fast and Frugal Heuristics. One line of research identifying inconsistencies and criticisms of the heuristics-and-biases program was Gigerenzer and colleagues' (Gigerenzer et al., 1999) proposal of fast and frugal heuristics. The most significant difference between these two approaches is that the heuristics and biases program focuses on how individuals diverge from the predictions of normative theories (Tversky & Kahneman, 1974), whereas the fast and frugal heuristics program focuses on how individuals apply simple heuristics to optimize their decisions (Gigerenzer, 2001). Nevertheless, both approaches have advanced the field of decision-making (Baron, 2012; Raue & Scholl, 2018). One example of the success of the fast and frugal heuristics program is its ability to create decision aids, such as decision trees, which have been particularly useful in medical decisions (Raue & Scholl, 2018). Decision trees provide a rule-based approach that uses real data to simplify complex tasks and support decision-making under uncertainty, helping to overcome biases and achieve accurate results with fewer questions, supporting fast and frugal decision-making (Hafenbrädl et al., 2016; Raue & Scholl, 2018).

The fast and frugal heuristics propose that individuals can use a set of simple heuristics (from the "*adaptive toolbox*") that can perform better than more complex strategies in many circumstances (Gigerenzer et al., 1999). The main objective of this approach is to demonstrate that heuristics do not need to be complex to be accurate (Hafenbrädl et al., 2016). Gigerenzer and colleagues (1999) state that

fast and frugal heuristics are *ecologically rational* because they combine cognition and environment; thus, they may outperform sophisticated algorithms in practical applications (Raue & Scholl, 2018; Todd & Gigerenzer, 2007). The research on fast and frugal heuristics is based on three building blocks: the first characterizes search rules, the second characterizes the stop rule, and the last characterizes the decision rule (Gigerenzer et al., 1999; Hafenbrädl et al., 2016). First, the search rule directs how information is explored, then the stopping rule outlines when to stop searching for information, and finally, the decision rule states how the final decision takes place (Gigerenzer et al., 1999; Hafenbrädl et al., 2016). The purpose of the heuristics is to be straightforward, easy to understand, and appropriate to the environment in which it will be used (Hafenbrädl et al., 2016; Raue & Scholl, 2018). For instance, it is hard to consider every aspect that influences a flying frisbee's trajectory, such as the spin and wind speed. In order to catch the object, humans and other animals use the gaze heuristic, which requires concentrating on the object while adjusting their running speed to maintain a constant visual angle (Gigerenzer, 2016; Raue & Scholl, 2018). Another example is the case of the pilot who saved 155 lives in the "*Miracle on the Hudson River*" who depended on a form of this heuristic to determine whether they could make it back to the airport or not after crashing with a band of geese (Gigerenzer, 2001, 2016).

1.3.1.2.3. Prospect Theory. Prospect theory is a behavioral theory of decision-making under uncertainty (applied to both situations of risk and ambiguity) developed by Daniel Kahneman and Amos Tversky in 1979. With this theory, the authors intend to explain why individuals violate fundamental axioms of the expected utility theory and claim that decisions are determined by individuals' subjective evaluations of a given outcome (Kahneman & Tversky, 1979). Namely, this theory accounts for two fundamental human biases in decision-making: loss aversion and the tendency to overestimate the importance of low probabilities and underestimate the importance of high probabilities (Kahneman & Tversky, 1979; McDermott, 2001; Tversky & Kahneman, 1981). Prospect theory analyses two aspects of the decision-making process: the framing phase and the evaluation phase (Kahneman & Tversky, 1979; McDermott, 2001; Tversky & Kahneman, 1981).

The framing stage is an important cognitive process that occurs before making a decision. This stage involves different procedures that simplify and provide a context for choice (Kahneman & Tversky, 1979). The framing phase includes several editing operations (Tversky & Kahneman, 1981), and the primary editing operations are segregation, coding, combination, and cancellation (Kahneman & Tversky, 1979). However, it also includes mechanisms such as simplification and the detection of dominance (for a review, see Kahneman & Tversky, 1979). After editing the options, the decision-maker evaluates them and selects the prospect with the highest worth (Kahneman & Tversky, 1979).

The subjective value function has several essential characteristics (Kahneman & Tversky, 1984; McDermott, 2001). The first is that the subjective value expresses a judgment made regarding state adjustments (losses and gains) relative to a psychologically neutral reference point instead of the absolute value of the outcome (Kahneman & Tversky, 1979). The status quo often represents the reference point (Kahneman & Tversky, 1979; Kahneman & Tversky, 1984; Tversky & Kahneman, 1981). The second important aspect of the subjective value function is that it is S-shaped, concave in the area of gains above the reference point, and convex in the area of losses (Kahneman & Tversky, 1979; Kahneman & Tversky, 1984; Tversky & Kahneman, 1981). The slope of the curve measures sensitivity to change, with the maximum sensitivity near the reference point and decreasing sensitivity as it moves away (Kahneman & Tversky, 1984). As a result, changes closer to the starting point have a more significant effect than more distant changes (Kahneman & Tversky, 1979; Kahneman & Tversky, 1984). This means that each additional unit has a diminishing value as gain or loss increases. For example, in the case of losses, the subjective value difference between losing 100 euros when you initially had 200€ appears more significant than the subjective value distinction between losing the same amount (100€) when you initially have 1200€ and end up with 1100€ (Kahneman & Tversky, 1984). The S-shaped curve suggests that individuals tend to take less risks in the context of gains and more risks in the context of losses (Kahneman & Tversky, 1979). According to the subjective value function, the third aspect is the value curve's asymmetric nature; it is considerably steeper in losses than gains (Kahneman & Tversky, 1979; Kahneman & Tversky, 1984). This last property is called loss aversion, implying that losing a determinant amount of money is more unpleasant than the pleasure of gaining it (Kahneman & Tversky, 1984).

Furthermore, prospect theory presented the concept of decision weights, which is the second component of the evaluation phase (Kahneman & Tversky, 1979; Tversky & Kahneman, 1981). Although Kahneman and Tversky (1979) assumed that decision weights were derived from probabilities, denoted as π(p), they clearly distinguished this concept from the conventional understanding of a probabilistic estimate since decision weights do not obey the probability axioms. (Edwards, 1962; Kahneman & Tversky, 1979). As used in prospect theory, decision weights should not be understood as objective probabilities or measures of belief (Kahneman & Tversky, 1979). Instead, they measure how much individuals value different outcomes or prospects (Kahneman & Tversky, 1979; McDermott, 2001). When making a decision, individuals assign subjective values and decision weights to each potential outcome, considering a future event's probability and consequential impact (Kahneman & Tversky, 1979). Kahneman and Tversky (1979) stated that to determine the overall prospect value V(x_i), the value of each outcome ($v(x_i)$) is multiplied by a decision weight ($\pi(p)$) In addition, the authors refer that the

decision weights (π) are found by applying a weighting function (w) to the actual probabilities (p); therefore, $\pi=w(p)$ (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992).

The weighting function has several essential characteristics. First, there is a lack of consistency at the extremes of the probability scale, where definitive certainty and absolute impossibility are situated (Kahneman & Tversky, 1984). For instance, individuals at times consider highly possible but uncertain occurrences as definite or highly improbable events as probable (Kahneman & Tversky, 1984; McDermott, 2001; Tversky & Kahneman, 1981). This implied that the weighting function demonstrates a poor behavior when reaching the endpoints (Tversky & Kahneman, 1981). Moreover, for both gains and losses, the weighting function overweights very small chances and underweights high chances (Kahneman & Tversky, 1979; Tversky & Kahneman, 1981, 1992). Individuals underestimating moderate and high probabilities when comparing to certain effects causes risk aversion in gains and risk-seeking in losses (Kahneman & Tversky, 1984). However, small probabilities are overestimated, and very small probabilities are either excessively weighted or neglected (Kahneman & Tversky, 1984). This overweight on small probabilities grows the value of risky bets and increases aversion to a small chance of a significant loss (Kahneman & Tversky, 1984). Consequently, individuals often seek risk when facing unlikely gains and are risk-aversive when facing unlikely losses (Kahneman & Tversky, 1984).

Insurance and lotteries are two classic examples of this (Kahneman & Tversky, 1984). In lotteries, individuals are willing to take a small but certain loss in exchange for a slight chance of making a substantial gain. When it comes to insurance, people are willing to accept a certain loss in order to reduce the likelihood of a subsequent future loss that would be significantly larger. Individuals may be risk averse despite the small likelihood of a loss in this circumstance. According to prospect theory, these differences are caused by the extreme (over)weight and attention that people give to small odds that could lead to either significant gains (e.g., winning the lottery) or significant losses (e.g., losing your home in a fire) (McDermott, 2001).

1.3.2. Effects of Uncertainty on Cooperation

Most studies on cooperation in social dilemmas have assumed that participants interact with complete knowledge of the dilemma's characteristics and the effects of all players' choices (van Dijk et al., 2004; van Lange et al., 2013). However, individual decisions are regularly made with incomplete information and inconsistent outcomes, so uncertainty and risk are frequent components of many social dilemmas (Bendor, 1993; Boone & Macy, 2004). For example, in social dilemmas, there is often uncertainty about the ultimate size of the public good or resource request, as subjects do not know what

their fellow group members will decide (van Dijk et al., 2004). Messick and colleagues (1988) refer to this uncertainty as "strategic uncertainty"; other researchers describe it as "social uncertainty" (Biel & Gärling, 1995; van Dijk et al., 2004). This dissertation will refer to this type of uncertainty as "social uncertainty".

Additionally, in most social dilemmas, the characteristics and parameters of the dilemma are usually known (van Dijk et al., 2004; van Lange et al., 2013). Nevertheless, in our daily lives, there are several situations where we can be uncertain about them. For instance, regarding climate change, it is unclear at what rate global warming will contribute to rising sea levels (Scambos & Abdalati, 2022). The terminology of "environmental uncertainty" was introduced to describe when group members may be uncertain about the characteristics and parameters of the dilemma (Messick et al., 1988).

1.3.2.1. The Effects of Social Uncertainty on Cooperation. In most cases, manipulations that reduce social uncertainty tend to increase cooperation in social dilemmas (FeldmanHall & Shenhav, 2019; Jorgenson & Papciak, 1981; Sniezek et al., 1990; van Dijk et al., 2004). For example, research has shown that participants cooperated more in a repeated social dilemma game when they received feedback regarding the contribution of others in the previous round compared to when they did not receive feedback (Jorgenson & Papciak, 1981; Sniezek et al., 1990; van Dijk et al., 2004). In a study conducted by Chen et al. (1996), the authors used a PGG with sequential choices, and their results suggested that uncertainty may confuse the perception of criticality (i.e., the perceived impact of one's choice on the outcome). In these experiments, social uncertainty decreases the higher participants' sequential position in the game. The authors argued that raising a sense of certainty in individuals may be necessary to improve their perception of criticality and effort (Chen et al., 1996). Results suggested that objective criticality (i.e., one's contribution towards the public good) does not consistently enhance cooperation, and the perception of criticality moderates its effect (Chen et al., 1996). Furthermore, the authors suggested that uncertainty is associated with criticality in their influence on perceived criticalness and cooperation. Results implied that when criticality was high, cooperation decreased with uncertainty (Chen et al., 1996). However, when criticality was low, there was a slight enhancement in cooperative behaviors with uncertainty (Chen et al., 1996).

In addition, research has suggested that uncertainty regarding the actions and intentions of others creates aversive feelings that lead individuals to limit the range of others' possible actions, thus making their own future more predictable (FeldmanHall & Shenhav, 2019). Therefore, individuals often rely on other factors related to the environmental characteristics and parameters of the dilemma when addressing social uncertainty (van Dijk et al., 2004). This can involve anchoring their decisions based on

fairness norms and social norms (van Dijk et al., 1999; van Dijk et al., 2004) or using past knowledge and contextual cues (FeldmanHall & Shenhav, 2019).

1.3.2.2. The Effects of Environmental and Outcome Uncertainty. Regarding the effects of uncertainty about the characteristics and parameters of the dilemma (Messick et al., 1988), research has shown that environmental uncertainty tends to reduce individuals' willingness to cooperate in several social dilemmas (e.g., Budescu et al., 1990; Gustafsson et al., 1999; van Dijk et al., 2004; van Lange et al., 2013). Studies using resource dilemmas have shown that uncertainty about the size of the resource led participants to overestimate the resource's size and increase their overharvesting behavior (Budescu et al., 1990; Gustafsson et al., 1999). One explanation for the effect of resource uncertainty on the harvesting behavior reflected an outcome-desirability bias by the individuals who are more inclined to overestimate the chances of positive outcomes (Gustafsson et al., 1999; van Dijk et al., 2004; Van Lange et al., 2013).

Regarding uncertainty in PGG, research has suggested that individuals contribute less when there is uncertainty about the characteristics of the public good, specifically when there is higher uncertainty about the limit of the provision (Dannenberg et al., 2015; van Dijk et al., 2004). A study by Gangadharan and Nemes (2009) examined how participants contribute toward a private or public account in a PGG when facing both social and environmental uncertainty (with risk and ambiguity treatments). In all conditions, the authors kept social uncertainty constant and introduced different forms of risk and ambiguity regarding the provision of private and public goods. Results revealed that contributions are significantly lower in the risk and ambiguity conditions than when there is only social uncertainty (Gangadharan & Nemes, 2009).

Another line of research has been attempting to understand how groups and individuals cooperate using two forms of the prisoner's dilemma: the Stochastic Prisoner's Dilemma (SPD) and the Deterministic Prisoner's Dilemma (DPD; Atanasov & Kunreuther, 2016; Gong et al., 2009, 2013; Kunreuther et al., 2009). The design adopted in these studies follows the Interdependent Security (IDS) games structure (Heal & Kunreuther, 2005; Kunreuther & Heal, 2003). In the IDS games developed, each individual has to decide whether or not they want to invest (i.e., investing in a measure that diminishes the risk) to decrease the risk of facing a more significant loss (Atanasov & Kunreuther, 2016; Gong et al., 2009; Kunreuther & Heal, 2003; Kunreuther et al., 2009). The deterministic version of the PD contains only social uncertainty - the game's possible outcomes depend on the other player's action, not on chance. In the Stochastic version of the PD, the outcomes of strategies have known probabilistic outcomes (i.e., risk). For example, each player knows that cooperation (i.e., deciding to invest) without

the other player's cooperation decision would lead them to losses with defined probabilities. One feature of the stochastic version of the game is that deciding to "invest" could be judged as a risk-aversive strategy since it reduces the likelihood of a significant loss and diminishes the discrepancy in the expected payoffs (Atanasov & Kunreuther,2016). However, choosing "not to invest" is the decision that minimizes losses (Atanasov & Kunreuther, 2016). The expected value of the probabilistic payoffs in the SPD game matches those in the deterministic condition (Kunreuther et al., 2009). In the deterministic version of the game, participants only have social uncertainty regarding what the others will decide. However, in the stochastic version of the game, participants must consider the other player's action and the outcome of the probabilities. In this game, results suggested that individuals appear to cooperate less in the SPD when risk is present compared with the deterministic version of the game.

Other studies also support these findings and report that individuals in a two-person PD are more prone to cooperate when payoffs are deterministic (the DPD game) than in the SPD games (e.g., Kunreuther et al., 2009). Additionally, Gong et al. (2009) found that although groups are more inclined to be less cooperative than individuals in the DPD game, the reversed effect was found in stochastic games (Gong et al., 2009). Furthermore, they described a learning process when participants play the game repeatedly: cooperation decreases as the number of rounds increases. Moreover, Kunreunther and collaborators (2009) suggested that participants seem to cooperate more in an SPD with full feedback than in an SPD with partial feedback. In the SPD game developed with partial feedback, participants find the other player's losses but not their decisions (Kunreuther et al., 2009). Therefore, receiving all information on the action and total outcome is important to improve cooperation.

Bereby-Meyer and Roth (2006) analyzed the learning effects, using games with outcome uncertainties in binary lotteries in all strategic possibilities (SPD), and compared them with DPD games. Participants either played a nonrepeated game (only one round with each partner) or a repeated game (ten rounds with the same partner). Findings from the repeated game revealed that in the deterministic condition, participants learn in the first few supergames to cooperate more in the early rounds and less in the last rounds. This pattern becomes even more apparent with experience. Nevertheless, there is less learning in the early rounds from one supergame to the next in the stochastic condition. The authors argued that participants learn to cooperate more slowly in the stochastic game than in the deterministic game due to the probabilistic payoffs, supporting the partial reinforcement learning (PRL) hypothesis. PRL is the procedure of occasionally rewarding a behavior, resulting in distinct learning patterns and behaviors compared to continuous reinforcement (Bereby-Meyer & Roth, 2006). In the presence of outcome uncertainty, since rewards are presented intermittently, it is known to slow down learning (Bereby-Meyer

& Roth, 2006). In the nonrepeated games, participants in the deterministic condition learn faster to defect over time and start playing the dominant strategy than in the SPD, where participants learn more slowly to decrease cooperation across rounds (Bereby-Meyer & Roth, 2006). The learned behavior in both games is similar, although the learning rate is slower in the SPD (Bereby-Meyer & Roth, 2006).

When the end period is of common knowledge to all participants (i.e., participants know how many rounds they will play against the other player), results imply a last-period effect in each supergame where participants cooperate less (Bereby-Meyer & Roth, 2006; Gong et al., 2009; Kunreuther et al., 2009). Participants seem to behave more strategically (Duffy & Smith, 2014). In the experiment of Fudenberg et al. (2012) using an infinitely repeated game, results revealed that participants tend to cooperate even when intended actions are implemented with uncertainty (i.e., the computer switched participants and the other player's choice with some probability) in situations where cooperation can be supported in equilibrium (i.e., both players start by cooperating and continue to do so until the first person defect). Some individuals even cooperate using strategies that involve leniency (slower to start defecting) and forgiveness (cooperate after the other chooses to defect; Fudenberg et al., 2012). Therefore, the authors concluded that forgiving others and cooperating in an uncertain world could be a payoff-maximizing strategy (Fudenberg et al., 2012).

In a study conducted by Artinger et al. (2012), the authors intended to determine how different levels of environmental risk and the form they are described affect cooperation rates. The study replicated the "description-experience" (DE) gap observed in lotteries involving risky decisions. In this case, results demonstrated that individuals take the risky option more often when they are in the condition of experiencing risky outcomes (i.e., individuals sampling the distribution of outcomes) than in the condition where they receive a summary description of outcomes and probabilities. However, the DE gap was not found in social dilemmas. In the stochastic PGG, participants were paying less attention to the observed probabilities in the experience condition than participants in the lotteries condition (Artinger et al., 2012). Thus, the authors indicated that this might explain the lack of effect in social dilemmas since individuals' risk perception in games was less accurate than in lotteries. In addition, participants in social dilemmas might prioritize the magnitude of values and beliefs about the behavior of others above outcome probabilities (Artinger et al., 2012).

Despite research suggesting that uncertainty has a detrimental effect on cooperation, other authors proposed that this is not always the case and might depend, among other factors, on the type of social dilemma, the type of uncertainty, and the level of risk (e.g., Boone & Macy, 2004; van Dijk et al., 1999; van Dijk et al., 2004). For instance, in recent research by Kappes et al. (2018), the authors found

that impact uncertainty (i.e., uncertainty as to how much the well-being of others will be affected by a particular outcome) promotes prosocial behavior. This topic remains poorly understood due to methodological differences in manipulating uncertainty and the difficulty in identifying simple principles that can explain all these results (Mantilla, 2018). Therefore, to better identify the influence of risk and uncertainty on cooperation, further research is needed to identify how the different uncertainty constructs impact cooperation (Vives & FeldmanHall, 2018).

1.3.2.3. The Effects of Risk Preferences on Cooperation. Previous studies have also focused on explaining the heterogeneity of behavior in cooperation through the influence of personal characteristics, such as risk attitudes (Dal Bó & Fréchette, 2018). However, findings regarding risk preferences and cooperation in PD are inconsistent (Dal Bó & Fréchette, 2018; Ng & Au, 2016). Several methods have been developed to assess an individual's inclination toward risk (De Heus et al., 2010). Some methods involve deciding between certain outcomes and uncertain gambles or deciding between different kinds of gambles (van Assen & Snijders, 2004; Parks, 2004), while other measures assess risk attitudes using psychometric scales to analyze risk-taking in specific or general domains of our daily lives (De Heus et al., 2010; Weber et al., 2002) or even computerized task to access risk-taking in a general domain (Lejuez et al., 2002). Research has suggested that risk-seeking individuals cooperated more in a repeated PD, and risk-aversive individuals cooperated less (Fung et al., 2012; Parks, 2004; Sabater-Grande & Georgantzis, 2002). On the other hand, other studies found that risk-aversive participants cooperated more than risk-seeking participants (Snijders & Raub, 1998; van Assen & Snijders, 2010). However, recent research did not find a strong relationship regarding risk attitude and cooperation in repeated PD (Davis et al., 2016; Dreber et al., 2014; Proto et al., 2019). Additionally, recent studies did not find a significant effect in a one-shot PD concerning risk orientation and cooperation (De Heus et al., 2010).

Glöckner and Hilbig (2012) suggested that the inconclusive effects of risk preferences on cooperation may depend on the environment of the social dilemma, such that cooperation is enhanced with dispositional risk aversion in environments where cooperation is usually more friendly. On the other hand, Au et al.(2012) and De Heus et al. (2010) reported that these inconclusive effects could be due to the difficulty in identifying risky decisions in PD games. For example, research has stated that deciding to cooperate in PD could be considered risk-aversive since it maintains an individual's reputation (Lam & Leung, 2007). Further research considered the strategy of deciding to cooperate as riskier in a PD once it implies a significant risk of the other players using them and, in turn, the participants obtain the worst outcome (Ng & Au, 2016; Parks, 2004). According to alternative explanations, cooperation could be

considered a more risk-taking or risk-aversive strategy, considering whether the results are characterized as gains or losses (Ng & Au, 2016; Raub & Snijders, 1997). Furthermore, Glöckner and Hilbig (2012) suggested that the riskiness of cooperation depends on the environment of the game, being riskier in an unfavorable environment for cooperation (where the value of K is low) and less risky in a favorable environment for cooperation (where the value of K is high).

Another way to conceptualize riskiness in PD is the game riskiness index (r; Au et al., 2012; Ng & Au, 2016). According to Au et al. (2012), in a PD, the potential risk of deciding to cooperate relative to the risk of the defection option can be determined as:

$$r = (R-S) / [(R-S) + (T-P)] \quad (4)$$

The index of game riskiness (r) ranges from 0 to 1 (Au et al., 2012; Ng & Au, 2016). The authors revealed that choosing to cooperate is riskier than deciding to defect in a game where the value of r is higher than 0.5. On the contrary, if the value of r is smaller than 0.5, cooperation is less risky than defection. However, if the distribution of cooperation outcomes is equal to the defection outcomes, it will have an r value equal to 0.5 (risk-neutral PD; Au et al., 2012; Ng & Au, 2016). In a one-shot PD game, Au et al. (2012) and Ng and Au (2016) found that risk-seeking individuals tend to cooperate more in games where cooperation is riskier ($r > 0.5$). In contrast, risk-aversive individuals cooperated more in games where cooperation is less risky ($r < 0.5$). Interestingly, in the article by Ng and Au (2016), the authors found that the expectation of cooperation leads to more cooperation, and the game's riskiness also moderated this effect. In this case, the anticipation of cooperation had a more significant impact on cooperation in riskier games and a weaker impact on cooperation in less risky games.

1.3.2.4. Impact of Time Constraints on Risky Decision-Making. Several studies have also tried to study the effect of time pressure on risky decisions (Kocher et al., 2019). Prior research on how time pressure influences risky decision-making has provided diverging results (Kocher et al., 2019; Olschewski & Rieskamp, 2021; Ordóñez et al., 2015). On the one hand, research has demonstrated that time pressure increases risk aversion, and there was a preference for negative aspects of the prospects (Ben Zur & Breznitz, 1981). On the other hand, studies have suggested that time pressure leads to higher risk aversion when the expected value of prospects is positive (Busemeyer, 1985) but lower risk aversion when the expected value is negative (Busemeyer, 1985; Maule et al., 2000).

More recently, studies have supported that individuals in the gain domain become less risk-aversive (more risk-seeking) under time pressure (Nursimulu & Bossaerts, 2014; Saqib & Chan, 2015) and more risk-aversive to losses (Saqib & Chan, 2015). Futhermore, Madan et al. (2015) discovered that individuals selected more risky options under time pressure in a gain domain and revealed that this effect

did not interact with other decision factors such as the DE gap, the probability or value of outcomes, or the extreme-outcome rule (high-value vs. low-value decisions).

In the study by Kocher et al. (2013), the authors found that time pressure does not affect risk preferences for gains and only affects choices with losses and mixed prospects. Results showed that time pressure increases risk aversion for losses. Regarding mixed-gambles effects, the authors provided evidence that participants were simultaneously more risk-aversive and risk-seeking under time pressure, depending on how the outcomes were framed. The authors suggest that participants under a time pressure condition were more loss-aversive and more gain-seeking (Kocher et al., 2013). Later, Kirchler et al. (2017) found different results, even though there were significant differences in the methodology between both studies, as the authors point out. The authors found that time constraint results in greater risk aversion in the gain frame and less risk aversion under losses than in the time delay condition (Kirchler et al., 2017). However, they did not find differences in risk-taking involving quick and slow preferences in mixed-domain gambles (Kirchler et al., 2017). Similarly to Kirchler et al. (2017), the study by Guo and colleagues (2017) has shown that individuals choose the sure option for gains (more risk-aversive) and the gamble option for losses (more risk-seeking) when individuals are required to make fast decisions.

Additional research indicates the complex relationship between these concepts (Ordóñez et al., 2015). For example, Dror and colleagues (1999) showed that the level of risk in a game moderates the effects of time constraints on risk preferences. Specifically, under time pressure, participants at lower risk levels were more risk-aversive but more risk-seeking at higher risk levels. Gawryluk and Krawczyk (2019) found that most individuals tend to be consistent in their decisions and are more risk-aversive; however, a non-significant minority of decisions get updated after individuals have more time to reflect. Furthermore, the results reported that most observed changes in participants' decisions after deliberation entailed that participants were more willing to take risks after deliberation. This effect was most evident in the case of unknown probabilities.

Even though previous studies indicate that time pressure influences individuals' risk preferences, Olschewski and Rieskamp (2021) did not corroborate these findings. In their study, they performed two experiments in which participants had to make repeated decisions between two risky gambles. The study aimed to investigate the effects of time pressure on risk-taking behavior by examining three explanations from previous research: (a) the impact of decisions under time pressure on risk preferences, (b) the reduction of choice consistency under time pressure conditions, and (c) the shift in strategy from a compensatory to a non-compensatory approach due to time pressure. Results indicated that choice

proportions differed between high vs. low time pressure conditions. The authors discovered evidence for declined choice consistency as the primary reason for the effect of time constraints on a shift in risky options (explanation b). However, the results did not prove that time pressure significantly influences an individual's risk preferences. Findings revealed some evidence of a strategy shift, where individuals appear more likely to adhere to a non-compensatory strategy under time pressure (Olschewski & Rieskamp, 2021). Yet the strategy shift could not explain the impact of time pressure on behavior, as choice consistency still declined even within compensatory strategies. This result is consistent with the understanding that most participants maintained a compensatory strategy even when facing time pressure. However, their execution of this strategy became less consistent when in a condition of high levels of time pressure. These findings suggest that time pressure may lead individuals to make less consistent choices when faced with risky decisions, regardless of their underlying risk preferences (Olschewski & Rieskamp, 2021).

Recently, Kocher et al. (2019) have also reported that in risky decision-making tasks, individuals with the ability to cope with limited time when observing time pressure in a task perform differently than those without this capacity. In sum, although recent research has helped to better understand these concepts, it is necessary to develop a more precise theoretical framework to clarify the mechanisms by which time pressure manipulation influences decision-making in risky situations (Ordóñez et al., 2015). We believe that examining the effects of time pressure on risky decision-making could be necessary, as considering the impact of time constraints on individuals' decisions in high-stakes situations may contribute to a better understanding of the effects of cognitive manipulations underlying cooperative behavior under risk.

1.4. The Dual-Process Approach to Human Cooperation

1.4.1. The Dual-Process Approach

One of the most distinct characteristics of human thinking is that certain processes are straightforward while others are more challenging (De Neys, 2021). For instance, imagine you are in a game show like "Who Wants to Be a Millionaire". If one of the questions is "What is the name of the current Portuguese President?", you will answer very quickly and without effort that it is Marcelo Rebelo de Sousa. However, if the question is "What is the name of the Portuguese President who succeeded António Spínola?" arriving at a decision (even with the four response options typically present in this game shows) will take more time and effort. Moreover, you will have to remember the history classes where you learned about the military presidency before starting the constitutional presidency.

Dual-process theories integrate a variety of conceptual frameworks whose primary principle is that individuals' decisions emerge from the interaction between two cognitive systems: one is considered to be quick and intuitive, while the other is considered to be slow and deliberative (Capraro, 2023; Evans, 2008; Evans & Stanovich, 2013; Rand, 2016). These theories can come in different forms, resulting in different classes of models that differ significantly among them (Capraro, 2023; Frankish & Evans, 2009). For example, these models can vary regarding the tasks these systems are assumed to execute (Capraro, 2023; Frankish & Evans, 2009). As a result, these theories may not be entirely compatible and may yield different and sometimes conflicting results (Capraro, 2023; Evans & Stanovich, 2013; Frankish & Evans, 2009). Based on the work of Stanovich (1999), the terms "System 1" and "System 2" became widespread in the literature to describe the characteristics attributed to intuitive and reflective thinking (Evans, 2018). Although these terms are still used by some authors (e.g., Kahneman, 2011), these systems were also denoted as "Type 1" and "Type 2" processes (Evans, 2018, 2019).

Since the 1970s, researchers have developed dual-process theories in many psychology domains, such as decision-making and social cognition (Evans, 2008; Frankish & Evans, 2009; Pennycook, 2018). Specifically, the study of biases in reasoning and decision-making can be related to the origin and development of dual-process theories (De Neys & Pennycook, 2019; Evans, 2019; Kahneman, 2011). Furthermore, in the last twenty years, there has been an exponentially growing number of scientific articles on prosociality through a dual-process perspective (Capraro, 2023; Pennycook, 2018). In addition, the precise timing of the production of Type 1 and Type 2 responses is the subject of an ongoing debate in the literature (Capraro, 2023; De Neys, 2018). Different models have been proposed to account for this discussion, such as the serial or default interventionist (DI) model, the parallel competitive model, and, more recently, the hybrid model (De Neys, 2018).

The serial or default-interventionist (DI) model has gained significant recognition over the years (De Neys, 2018), and several researchers have supported this model (such as Evans, 2006; Evans & Stanovich, 2013; Kahneman, 2011; Stanovich, 2009). The fact that there is a sequential perspective of the interaction between the Type 1 and Type 2 processes is a fundamental element of the DI model (De Neys, 2018). In Evans and Stanovich's (2013) work, the authors posited that the defining feature of Type 1 is the fact that it is autonomous, meaning it is not consciously controlled or engages working memory (Evans, 2018; Evans & Stanovich, 2013). On the other hand, the Type 2 processes' key trait is that it requires working memory (Evans & Stanovich, 2013). Working memory provides temporary information storage and permits different types of manipulations involved with reasoning (Baddeley, 2003). Cognitive

decoupling and mental stimulation are also defining features of deliberate thinking, which involves conscious effort and control over one's thoughts and actions (Evans & Stanovich, 2013).

DI models suggest that individuals who face a reasoning problem usually choose their Type 1 system as their default system to formulate a solution (De Neys, 2018). However, Type 2 engagement is intentional and only occurs after Type 1; individuals can use a Type 2 system to correct a previously obtained Type 1 response (De Neys, 2018). The DI model assumes that individuals try to minimize cognitive effort by avoiding engaging in Type 2 responses since it is demanding, and instead, they rely on their default response (De Neys, 2018; Kahneman, 2011). As a result, this theory makes two critical assumptions (Bago & De Neys, 2020). One assumption is that most individuals that use heuristic Type 1 response will not notice conflicts between heuristics cues and more rational considerations, such as those found in a standard classic reasoning task (Bago & De Neys, 2020; De Neys, 2018). In this situation, biased reasoners who initially gave a heuristic response inconsistent with logical principles are unlikely to identify that their answers are incompatible with logical principles (Bago & De Neys, 2020; De Neys, 2018). This assumption is called the "bias blind spot" hypothesis (Bago & De Neys, 2020; De Neys, 2018). The second assumption the DI model implies is that when there is a conflict between logic principles and heuristic responses, Type 2 responses are needed to overcome the heuristic Type 1 response and reach the more rational response (Bago & De Neys, 2020; De Neys, 2018). This hypothesis is referred to in the literature as the " corrective " assumption (Bago & De Neys, 2020; De Neys, 2018).

Previous research that identified the typical features associated with the Type 1 and Type 2 process has led to the development of some fallacies (Stanovich, 1999; Evans & Stanovich, 2013; Evans, 2018). For instance, Evans and Stanovich (2013) referred to the normative fallacy, which states that usually Type 1 process leads to biases, and the Type 2 process leads to the normatively correct answer (Evans, 2018). One explanation for these two features is that they are frequently correlated with the type of problems investigated (De Neys, 2018). Generally, in these problems, there is a need for more deliberation to give an accurate answer (De Neys, 2018; Evans, 2012). Naturally, the Type 1 response can also be accurate, and there are situations where deliberate and analytical thought may give an incorrect response (De Neys, 2018).

The DI model, with the bias blind spot and corrective assumptions, has significantly influenced thinking in several domains that have supported dual-process models (Bago & De Neys, 2020). However, recent studies regarding the hypothesis of the DI model have shown some issues (Bago & De Neys, 2020). The conflict-detection paradigm was applied to test whether biased reasoners could understand when their answers went against logic considerations by choosing an intuitively cued response instead of

the logical one (Bago & De Neys, 2020; De Neys, 2018). Some researchers testing the bias blind spot hypothesis proposed that biased reasoners show bias sensitivity (Bago & De Neys, 2020; De Neys, 2018), yet other studies did not reveal an overall bias conflict (Ferreira et al., 2016; Mata et al., 2014). New evidence also challenges the corrective hypothesis (Bago & De Neys, 2020). For instance, results from studies employing a two-response paradigm (see Thompson et al. 2011) suggest that correct responses can be generated intuitively without deliberation (Bago & De Neys, 2020). In this paradigm, individuals were asked to share their immediate intuitive response to a reasoning problem, followed by the opportunity to reflect (for as long as they want) and come up with a final response (Bago & De Neys, 2017; De Neys & Pennycook, 2019). Furthermore, recent findings indicated that many reasoners who provided a logical response (i.e., when deliberation was encouraged) had previously provided this result during the first response stage when they had to use intuition (Bago & De Neys, 2020).

The most well-known traditional competitor of the DI model is the parallel processing model (Epstein, 1994; Sloman, 1996). In contrast to the serial model, the parallel processing perspective suggests that both Types 1 and 2 are activated at the same time since the start of the reasoning process (De Neys, 2018; Epstein, 1994; Sloman, 1996). Although this model assumes parallel processing of distinct problem features, that does not indicate that the Type 2 process will always be completed. Nevertheless, it is sufficient to detect conflicts between logical principles and heuristic responses (De Neys, 2018; Bago & De Neys, 2020). Still, similarly to the DI model, it implies that signaling the correct response requires a Type 2 response that takes time and effort (Bago & De Neys, 2020).

A recent line of study, the hybrid model, challenges the previous models and argues that individuals can process basic logical principles intuitively (De Neys, 2018, 2021). This new model explains that Type 1 responses can reveal logical responses that are usually presumed to be only caused by Type 2. In this case, the hybrid model assumes that the Type 1 process generates at least two intuitive responses (De Neys, 2018). One of these responses is the typical intuitive "heuristic" response that has also been shown to be intuitively displayed by serial and parallel models. The second refers to a "logical" intuitive response that involves understanding fundamental logical and probabilistic concepts (De Neys, 2018). This new model's central hypothesis is that individuals unconsciously comprehend basic probabilistic and logical concepts and automatically apply these notions whenever a reasoning problem is given, even when biased. In the case of a conflict situation, individuals with this intuitive, logical knowledge can recognize that the heuristic intuition is questionable without having to engage in a Type 2 process (De Neys, 2018).

Even if dual-process models are recognized and popularized, single-process model proponents have objected to them (De Neys, 2021; Kruglanski & Gigerenzer, 2011; Melnikoff & Bargh, 2018). As previously explained, the dual process models suggest that intuition and deliberation are viewed as two distinct cognitive processes with different characteristics. (De Neys, 2021). Single process theories, on the other hand, suggest there is no qualitative difference (De Neys, 2021). Instead, these theories propose that cognitive processing occurs along a continuum (De Neys, 2021; Melnikoff & Bargh, 2018; Pennycook et al., 2018). In sum, single-process theories assert that there is no fundamental difference between Type 1 and Type 2 and that all cognitive processes are related to and impact one another (De Neys, 2021). Nevertheless, single-process theories also assume that individuals may distinguish between a more intuitive and deliberative form of thinking (De Neys, 2021; Melnikoff & Bargh, 2018). However, according to this theory, this distinction is a matter of magnitude and not a distinction between different types of categories, as the dual process affirms (De Neys, 2021). Research has implied that dual and single-process theories have influenced the field and produced some advantageous outcomes (De Neys, 2021).

This doctoral thesis will not focus on the moment when Type 1 and Type 2 responses are generated. Instead, in the studies addressed in this thesis, we will only focus on the distinctions of the characteristics of the dual process approach, more specifically, on the distinction between intuitive and deliberate thinking. Both intuition and reflection play a crucial role in studying human behavior. Intuition involves fast, automatic, and effortless mental processing that is believed to generate default responses. On the other hand, deliberation involves distinct higher-order reasoning processes that are slower and more controlled (Capraro, 2023; Evans & Stanovich, 2013; Kahneman, 2011). Research that investigates the decision-making process in a more intuitive or reflective setting has made significant progress in advancing theoretical debates involving the dual-process models and allowed the development of theoretical frameworks across several domains of judgment and decision-making, moral dilemmas, cooperation, and prosocial behavior (Capraro, 2023; Isler & Yilmaz, 2022; Rand et al., 2012).

1.4.2. The Cognitive Basis of Cooperation

Specifically, a growing body of experimental research examined the relationship between cognitive processes and cooperation (Capraro, 2023; Rand, 2016; Rand et al., 2012). These studies primarily used cognitive process manipulation methods (e.g., time constraint, conceptual primes, cognitive load, ego depletion; for a review, see Capraro, 2023; Kvarven et al., 2020; Rand, 2016).

Rand and colleagues (2012) were the first to reveal that using time pressure manipulation and conceptual priming of intuition increases cooperative behavior. The authors demonstrated this effect in a

wide range of experimental designs in the laboratory and online studies, using several one-shot PGG. The authors also analyzed data from prior social dilemma experiments where the response time was recorded. They examined data from a series of one-shot PD, a repeated PD with noise[2], a repeated PD game with and without costly punishment, and a repeated PGG including or not the possibility to reward and/or punish (Rand et al., 2012). The authors analyzed the behavior during the initial round of every experimental session and observed a negative relationship between response time and cooperative behavior (Rand et al., 2012).

Regarding the repeated games' results, supplementary information clarified that the relationship between cooperation and decision time decreases with experience (Rand et al., 2012). Two experiments obtained a statistically significant effect when evaluating the first ten periods but not when analyzing all periods. However, when analyzing data from the repeated PD with noise (results from Fudenberg et al., 2012) and the study of the stochastically repeated PD with/without costly punishment (results from Dreber et al., 2008), results showed a significant negative effect between response time and cooperation when evaluating all decisions made throughout the session. Nevertheless, the coefficient is smaller across the session than the coefficient from the first period (Rand et al., 2012).

These findings were replicated in additional studies that revealed that time pressure increased cooperation among naive individuals (who do not have previous experience with social dilemma games) and among individuals with high levels of interpersonal trust (Rand & Kraft-Todd, 2014; Rand et al., 2014). Based on the previous observations, Rand and colleagues (2014) developed a theory that explains when intuition is going or not to affect cooperation – The Social Heuristics Hypothesis (SHH; Bear & Rand, 2016; Rand, 2016; Rand et al., 2012). The SHH uses a dual-process perspective to extend several theories from the field of psychology and biology that have claimed that cooperative decisions are influenced by individual behaviors that have been successful in past social interactions (Rand, 2016). According to the SHH, the behavior usually advantageous in everyday social relationships (i.e., that increases outcomes in the long run) becomes internalized and is automatically applied as a social heuristic or an intuitive default response (Capraro, 2023; Rand et al., 2012; Rand et al., 2014; Rand, 2016). This theory may explain the results previously found in Rand et al.'s original study (2012) since participants brought these intuitive responses into laboratory experiments and cooperated under intuition in one-shot social dilemma games, where cooperation is not payoff maximizing (Rand et al., 2014). However, through more reflective processes about the situation, individuals can override the behavior

[2] In the experiment of Fudenberg et al. (2012), noise was implemented in the form of a probability that each player's intended action would be "*flipped*" to the opposite action with a specific probability. Participants received feedback of the actions that were taken, but they were not informed about the actual move chosen by the other player (i.e., intended action; Fudenberg et al., 2012).

toward the optimal behavior for a particular situation (Capraro, 2023; Cone & Rand, 2014; Rand, 2016; Rand et al., 2014).

However, in our daily lives, cooperation can be considered a payoff-maximizing behavior due to repeated interactions, reputation, and social norms (Rand, 2016; Rand et al., 2014). For example, consider a scenario where a person has a history of being cooperative. In such cases, other individuals will likely reciprocate that behavior and opt to cooperate as well. In this situation, self-interest influences individuals to cooperate (Rand et al., 2014; Rand & Nowak, 2013; Fudenberg et al., 2012). However, this should not be the case for everyone since, even when reciprocity is available, if the majority of the individuals with whom a person interacts choose to defect, it becomes advantageous to maximize personal gains by defecting as well (leading to the formation of non-cooperative intuitions; Rand & Kraft-Todd, 2014). As a result, promoting deliberation should only weaken cooperative behaviors among individuals with cooperative interaction partners (that is, individuals who have acquired cooperative intuitions; Rand & Kraft-Todd, 2014). Therefore, individuals in an environment where most other individuals are uncooperative should not be affected by manipulating cognitive processes in the one-shot social dilemma since defection is their default behavior (Rand et al., 2014; Rand & Kraft-Todd, 2014).

Rand (2016) refers to *pure* cooperation in situations where future encounters are unlikely, and there is no self-interested motive to cooperate. In this situation, it is not payoff maximizing to cooperate, and the SHH predicts that in this situation, deliberation in social dilemmas will favor noncooperation, and intuition will favor cooperation. On the contrary, in situations where future encounters exist, individuals can have self-interested motives to cooperate. Therefore, Rand (2016) called cooperation *strategic*. In this situation, the SHH predicts that deliberation in social dilemmas can favor cooperation or defection based on each individual's beliefs about which behavior will optimize his or her outcome (Rand, 2016). These beliefs can vary based on, for example, the expectations about how others will act (Rand, 2016). Social heuristics are flexible because they can adapt and change based on experiences and the feedback received from interacting with others (Jordan et al., 2015; Rand et al., 2014)

Numerous studies have attempted to test the SHH experimentally and understand its correlates by applying different cognitive process manipulation techniques (Capraro, 2023; Isler & Yilmaz, 2019). Results from a meta-analysis that explored the effect of time pressure and other cognitive process manipulation on cooperation supported SHH's prediction (Rand, 2016). Findings from this meta-analysis revealed that intuition increases cooperative behaviors in one-shot games but not in repeated games (Rand, 2016). Furthermore, recent studies using improved methods and addressing previous questions

regarding participants' exclusions, selection bias, and comprehension checks have found evidence for the SHH (Everett et al., 2017; Isler et al., 2018; Isler & Yilmaz, 2019).

The positive effect of more cooperative behavior when asked to respond more quickly than when asked to deliberate was even found in a PGG with a competitive frame (Cone & Rand, 2014; Rand et al., 2015) and when making decisions regarding out-group members in a PD (Everett et al., 2017; Rand et al., 2015). Additionally, Everett et al. (2017) investigated the SHH in a one-shot PD game with in-group and out-group members in both gain and loss frames while addressing methodological limitations by including an unconstrained control condition, ensuring compliance with time manipulations and controlling for participants' understanding of the game's structure (Everett et al., 2017). Results demonstrated that individuals tend to cooperate more when subjected to time pressure manipulation. The positive effect of intuition on cooperation is also found in out-group members and in a loss frame context (Everett et al., 2017). In these studies, the positive effect between time pressure and cooperation generalizes previous knowledge by demonstrating this effect in situations where cooperation is less favorable (Cone & Rand, 2014; Rand et al., 2015). Also, these results imply that participants do more than follow the social norms that a given setting alludes to or by participants considering that cooperation is the expected behavior or required in a laboratory setting (Cone & Rand, 2014; Rand et al., 2015).

Besides experiments on time manipulation, other studies using conceptual primes also revealed that intuition favors cooperative behaviors (Levine et al., 2018; Lotz, 2015). For example, research has observed that priming intuition, compared to priming deliberation, increases cooperation even in a one-shot asymmetric PGG where cooperation should not be expected (Lotz, 2015). Additionally, priming participants to rely on emotion also increases cooperation and prosociality, compared to priming participants to rely upon reason (Gärtner et al., 2022; Levine et al., 2018). Furthermore, in the study of Levine et al. (2018), participants also expected emotionally based decision-makers to be more cooperative than those who relied on reason. Using a cognitive load manipulation in a PGG game, Døssing et al. (2017) found that cognitive load leads to an increase in cooperation in the first round. The authors concluded that they increasingly rely on this heuristic when cognitive resources are unavailable to calculate costs and benefits. Furthermore, the authors suggested that the lack of cognitive resources may cause individuals to adopt a more cooperative heuristic or to apply a heuristic that suggests an intermediate choice is a safe strategy (Døssing et al., 2017).

However, some studies using one-shot games, replication attempts, and re-analysis of previous data did not find an effect of the SHH hypothesis (Bouwmeester et al., 2017; Camerer et al., 2018; Tinghög et al., 2013; Verkoeijen & Bouwmeester, 2014). For example, in a series of five experiments,

Tinghög and colleagues (2013) tested the robustness of previous findings from Rand et al. (2012). In their experiments, they did not exclude from the analysis participants who did not answer within the stipulated time manipulations, and the results found no overall effect of time pressure on cooperation (Tinghög et al., 2013). However, Rand et al. (2013) later replay and conducted a re-analyzes of their study 6 and 7 and included in the analysis subjects who failed to obey the time constraint. Similar to the results from the original analyses, they revealed a significant positive effect of time pressure on cooperative behavior (Rand et al., 2013).

Nevertheless, a large-scale multi-lab replication of study 7 by Rand et al. (2012) failed to find a strong effect (Bouwmeester et al., 2017). Instead, this study replicated the effect previously found by Tinghög et al. (2013) that time pressure manipulation promotes cooperation only when non-compliant individuals had been isolated from the analysis (Bouwmeester et al., 2017). Furthermore, in three online experiments, Verkoeijen and Bouwmeester (2014) contrasted players' contributions to a one-shot PGG under time pressure and after a forced delay. The results contradicted Rand and colleagues' (2012) findings and revealed a small, non-significant negative intuitive cooperation effect from the combined effects of the meta-analysis realized with effects from the three experiments (Verkoeijen & Bouwmeester, 2014).

On the other hand, other studies (Capraro & Cococcioni, 2016; Goeschl & Lohse, 2018) have found the opposite effect from Rand and collaborators (2012). For example, in the first experiment conducted by Capraro and Coccocionni (2016), the authors described that cooperation rates are lower in a one-shot PD under extreme time pressure conditions. In Goeschl and Lohse's (2018) experiment, participants played a one-shot and repeated PGG. Results indicated that time pressure decreased contributions in the one-shot PGG but did not affect contributions in the repeated game. Based on previous literature, the authors suggested that employing self-control over time becomes more challenging and that self-control could be necessary for cooperation (Goeschl & Lohse, 2018). In this case, there might be a decrease in contributions in repeated games due to the depletion of self-control resources (Goeschl & Lohse, 2018).

Furthermore, studies employing time-pressure manipulation have been questioned regarding their validity (Myrseth & Wollbrant, 2017). In a recent study by Myrseth and Wollbrant (2017), the authors reviewed data from the first studies conducted by Rand and colleagues (Rand et al., 2012; Rand et al., 2014). The authors reported that most of the responses were slow in these studies and suggested that the decisions could be interpreted as being made under deliberation (Myrseth & Wollbrant, 2017). Specifically, they suggested that time limits longer than 5 seconds may not be short enough to produce

intuitive responses, resulting in low-deliberation conditions (Myrseth & Wollbrant, 2017). Additionally, using ego depletion as a cognitive process manipulation in the second experiment of Capraro and Cococcioni (2016), results revealed that reducing participants' self-control leads to less cooperation in a one-shot PD. However, this effect only appears to occur among participants with no previous experience with the game (Capraro, 2023; Capraro & Cococcioni, 2016). In addition, studies using short-term hunger found no effect on cooperation (Rantapuska et al., 2017). A recent meta-analysis by Kvarteen and colleagues (2020) failed to obtain robust evidence for the SHH when examining the overall meta-analytic effect. Although the authors found evidence favoring an overall positive impact of the intuitive decision-making process on cooperation, the authors stated that this result could be driven by conceptual primes (emotion-induction manipulations) requesting individuals to concentrate on emotional decisions vs. reasoning decisions (Kvarven et al., 2020).

Another line of research, the Self-Control Account (SCA), argues that humans are inherently selfish (Isler & Yilmaz, 2019). Contrary to the SHH, this theory argues that individuals have an instinctive predisposition towards selfish behavior driven by temptation and that cognitive resources are needed to control these impulses and act following individual preferences or socially desirable ends, drawing on self-control strategies to encourage goal-pursuit (Hofmann et al., 2009; Isler & Yilmaz, 2019; Myrseth & Fishbach, 2009). Therefore, according to this theory, people use self-control to overcome these impulses and act cooperative and prosocial (Myrseth & Fishbach, 2009). SCA posits that without these cognitive resources, the natural human tendency is to prioritize self-interest over the group's interest (Isler & Yilmaz, 2019). For example, a worker might be inclined to free-ride on a group activity and go home earlier. Nonetheless, the ability of the worker to see such behavior as conflicting with his beliefs could allow him to stay away from temptation by eliciting positive thoughts about cooperating with his colleagues (Myrseth & Fishbach, 2009). The SCA is compatible with the explanation of strong reciprocity as a deliberated preference for obtaining a socially desirable end (Isler & Yilmaz, 2019). Research has also revealed a positive correlation between cooperation and self-control (Kocher et al., 2017; Martinsson et al., 2014) and cognitive abilities (Lohse, 2016).

A more general point of view seeks to provide a complete cooperation account, combining the two perspectives presented (Isler et al., 2021; Isler & Yilmaz, 2019). The authors conducted two experiments in which participants played one-shot PGG under time constraints manipulation, where the game could be played in Provision (participants contribute to the public good) and Maintenance (participants withdraw from the public good; Isler et al., 2021). These experiments revealed that cooperation is higher in Provision than in Maintenance dilemmas. Likewise, results also demonstrated

that the measures of strong reciprocity (preference for conditional cooperation), which included expectations and preferences for conditional cooperation, are lower in Maintenance than in Provision dilemmas. Still, cooperation in both dilemmas stays high despite deliberation, and results revealed that preferences for strong reciprocity anticipate cooperation (Isler et al., 2021).

Regarding the comparison between time-limit manipulations, deliberation increases defection in Provision games but elicits cooperation in Maintenance games. This result suggests that SHH's assumption regarding intuitive cooperation was not confirmed for Maintenance dilemmas, whereas SCA's assumption of intuitive selfishness can explain this effect (Isler et al., 2021). In other words, deliberation increases cooperation when social dilemmas induce selfish heuristics (when cooperation requires preserving an already existing public good) but not when they encourage prosocial heuristics (when it involves giving to a nonexistent public good; Isler & Yilmaz, 2019). The study argues that the Contextualised Strong Reciprocity framework merges the distinct processes involved in SHH and SCA by joining effects induced by the different intuitions (Isler et al., 2021; Isler & Yilmaz, 2019). Therefore, this study discusses that the value of each type of intuition may change according to contextual circumstances, such as the kind of social dilemma presented (Isler et al., 2021). The divergent results found in the literature for the SHH and SCA imply that missing moderators should be considered (Isler & Yilmaz, 2019). Furthermore, literature has indicated that the majority of studies examining the effects of time constraints in social dilemma games have been developed in a one-shot setting. (Goeschl & Lohse, 2018).

In the experiment of Duffy and Smith (2014), the authors manipulated subjects' cognitive load while playing a repeated four-player PD. Participants memorize fewer digit numbers in the low cognitive load condition, while participants in the high cognitive load condition memorize more digits. Participants were asked to recall the number at the end of each decision. Results revealed that participants under a high cognitive load exhibited less strategic behavior in a repeated PD than those under a low cognitive load. In addition, participants' behavior in both conditions converged to the Subgame Perfect Nash Equilibrium behavior. Participants in the low-load condition demonstrated more strategic defection at the end of the game and could better base their decisions on factors related to past outcomes. The authors found no evidence that participants were influenced by a difference in the final payoff rather than by a difference in cognitive manipulation. Duffy and Smith (2014) suggested a negative association between cognitive ability and strategic behavior measures (both end-of-game defection behaviors and the capacity to base their decisions on previous outcomes).

Several studies have also found that cooperation decreases across repeated rounds (Bereby-Meyer & Roth, 2006; Fehr & Fischbacher, 2003; Gong et al., 2009). This effect can be triggered by individuals who cooperate until they learn that their interaction partners start defecting, termed 'conditional cooperators' (Fischbacher et al., 2001; McAuliffe et al., 2018). In addition, other studies, when analyzing repeated interactions, have found that individuals' decisions are affected by the past actions of their interaction partners (Fudenberg et al., 2012; Nishi et al., 2016; Santa et al., 2018). Research has also shown that reciprocal decisions are made more quickly, implying that the social environment influences how fast cooperative decisions are made (Nishi et al., 2016). Later, Gallotti and Grujić (2019) revealed the same effect using a drift-diffusion model and that in a non-cooperative environment, cooperative decisions are only quicker in the initial round. The authors revealed that deliberation becomes dominant if the decision process is repeated over an initial intuitive bias toward cooperation. Furthermore, results revealed that as participants learn the game, their ability to gather information increases as the process becomes more effective, allowing participants to make faster and more rational decisions (Gallotti & Grujić, 2019). The authors also found that the predisposition towards cooperation returned to the same value as in the beginning after a pause (Gallotti & Grujić, 2019).

1.4.2.1. Intuition and Deliberation in Cooperation: Children and Field Studies. Recently, scholars have started exploring the influence of deliberation and intuition on prosocial behavior in infants and children (Corbit et al., 2022; Grossmann et al., 2020; Plötner et al., 2021). For example, Grossmann et al. (2020) revealed that between 14 and 18 months, helping behavior improves by becoming faster and more frequent. Furthermore, the results suggested that prosocial behavior is automated long before toddlers are socialized into the norms of cooperation (Grossmann et al., 2020). These results are consistent with the intuitive cooperation framework's premise that cooperation is essential for our evolutionary history and advantageous in daily life (Grossmann et al., 2020).

Moreover, two recent studies also indicate an intuitive propensity to cooperate among children (Corbit et al., 2022; Plötner et al., 2021). Results reveal that children share more stickers in a time pressure condition than children in a time delay condition (Plötner et al., 2021). Additionally, it was found that children became more cooperative with age since older children share more stickers than young children (Plötner et al., 2021). Recently, Corbit et al., 2022 developed a child-friendly version of the repeated PGG from Rand et al. (2012). The authors discovered that children were more willing to cooperate under time pressure than when decisions were made unconstrained. However, under reflective thinking induced by the time delay condition, children did not increase cooperation relative to the time-neutral condition (Corbit et al., 2022). Moreover, the authors discovered that children's assessments of

other players' cooperative responses predicted whether or not their intuition supported cooperation. Specifically, when children believed that the other players were generally cooperative, the intuitive behavior was to cooperate. However, when children believed other players were typically selfish, time pressure did not affect their choices. The results of these three studies corroborate Rand and colleagues (2012) and (2014) work and suggest an intuitive prosocial propensity.

Nevertheless, in a recent study, researchers discovered that the processes underlying cooperation do not follow a straightforward pattern throughout life (Nava et al., 2023). As individuals grow, their intuitive processes lead them to adopt more cooperative norms as they gain experience with the benefits of cooperation. The inclination towards intuitive responses favoring cooperation increases with age, and results revealed that young adults and older adults cooperate more under time pressure. Yet, adolescents tend to cooperate more when they have time to think than under a time pressure condition. The authors indicated that individuals learn about the benefits of cooperation through their life experiences and exposure to cooperative environments (Nava et al., 2023).

Recently researchers also intended to examine how intuition and deliberation influence cooperative behavior using a natural field experiment (Artavia-Mora et al., 2017). In a recent study conducted by Artavia-Mora et al. (2017), participants were in a park and were randomly allocated to a condition where: a) they either saw an actor drop a personal item (helping a stranger dilemma), or b) they saw an actor throw an empty plastic bottle then he dropped a glove (helping a norm violator), or c) they only saw the actor throwing the plastic bottle (punishment of a norm violator). Participants had a short or extended period to choose whether to help. In this case, a longer distance encourages careful reactions, and a small distance prompts quick reactions. Results revealed that participants intuitively tend to help others. Participants in a time delay decreased the likelihood of helping strangers and helping rates dropped overall in the second dilemma (helping a norm violator; Artavia-Mora et al., 2017). Overall, the findings from this field study are consistent with previous laboratory experiments by Rand et al. (2014). This study was critical since it investigates helping behavior without strategic interactions generally present in laboratory experiments using social dilemmas (Artavia-Mora et al., 2017).

1.4.2.2. Intuition and Deliberation in Cooperation: Potential Moderators. Lately, studies have started exploring the role of potential moderators of cooperation and found support for the SHH predictions (Capraro, 2023). In the general study of cooperation, two meta-analyses did not reveal gender differences between women and men in cooperative behavior (Balliet et al., 2011; Spadaro et al., 2023). Rand (2017) focused on the moderating impact of gender when analyzing the results of a meta-analysis studying the effect of intuition on cooperative social dilemmas. Using meta-regression, the

authors contrasted the moderating role of gender in social dilemmas involving cooperation vs. giving decisions in the DG (altruism). Results supported the predictions made by the SHH and found no significant interaction between gender and intuition in social dilemmas that study cooperation (Rand, 2017). In contrast, the DG-given studies showed a larger gender-intuition interaction effect size, where intuition favored prosocial behavior in women and did not find an effect for men. Findings from this meta-analysis validate the predictions of the SHH and support previous findings from Rand and colleagues (2016) that revealed gender differences in the study of altruism (Rand et al., 2016).

Studies have shown that participants who experience a more cooperative environment (i.e., a high trade-off between cost and benefit and positive payoffs for engaging in mutual cooperation) and are more trusting tend to cooperate more under intuition (Capraro, 2023; Capraro & Cococcioni, 2015; Rand & Kraft-Todd, 2014). Capraro and Cococcioni (2015) did not find an effect between time constraints and cooperation among subject residents in India with no previous experience with economic games. However, they reported that experience positively affects cooperation, which is significant only for participants under time-pressure conditions (Capraro & Cococcioni, 2015). When considering all the subjects, the working paper by Strømland and colleagues (2018) failed to find an effect of the SHH. However, the authors proposed that payoff comprehension can explain the failure to replicate the SHH finding; time pressure positively affects cooperation only for those who understand the game's payoff structure. They explained this effect using their experiment's results and a re-analysis of previous data (Strømland et al., 2018). In a later study, Isler et al. (2018) also revealed a positive effect of intuition on cooperation when individuals understand the social dilemma.

A recent study found that reading anti-free will messages led to decreased donations to a public good, suggesting that reducing belief in individuals' free will increases the likelihood of uncooperative behavior (Protzko et al., 2016). The effect was observed only in the time pressure condition, suggesting that the shift in behavior operates on intuitive processes. The study suggests that challenging an individual's belief in free will can temporarily change their default behavior and cause them to act in their self-interest (Protzko et al., 2016). Recently Protzko et al. (2019) suggested that the effect of time constraints on social desirability was moderated by an individual's belief that their true self is mainly good. Results from this study support the SHH, suggesting that when time is limited, participants' answers align more with internalized social norms. The authors imply that participants may show aspects of their desired good self when given time to respond (Protzko et al., 2019). However, under time pressure, individuals seem to conform to internalized social norms to appear favorable to others (Protzko et al., 2019).

Furthermore, a recent study supports the notion that previous social interaction experiences shape whether or not cooperation is the intuitive response (Gao et al., 2020). Results from this study revealed a positive association between attachment anxiety and cooperation and a negative association between attachment avoidance and cooperation under intuition (Gao et al., 2020). Additionally, there was no significant effect between attachment style and cooperation in a deliberative condition (Gao et al., 2020). Evidence also showed that while time pressure increased cooperation in men with a low-risk factor score, it decreased cooperation in men with a high-risk factor score (Bird et al., 2019). By exploring the cognitive processing manipulations on the cooperative behavior of individuals with different levels of social value orientation (SVO), a recent study found that pro-selfs generally requested less money in a deliberative mode, indicating that their concern for fairness is strategic. On the other hand, prosocial individuals made equivalent requests in intuitive and deliberative conditions, demonstrating a propensity to adhere to the equality rule intuitively (Lu et al., 2018). Later, Alós-Ferrer and Garagnami (2020) did not reveal a general effect of time pressure manipulation on cooperation. Nonetheless, the authors found that time pressure interacted with SVO, making prosocial individuals even more prosocial, leaving moderately individualists unaffected, and making competitors and high individualistics more competitive. The authors conclude that intuition elicits default behavior in the context of social cooperation but that this behavior depends on individual differences (Alós-Ferrer & Garagnani, 2020).

1.5. The Present Dissertation

This doctoral thesis focuses on a current field of research that investigates the cognitive foundations of prosocial behavior (Capraro, 2023). In particular, we propose to clarify the cognitive processes that underlie cooperative decision-making involving some level of risk and uncertainty through the experimental manipulation of time pressure. Even though there is a controversy over the use of time constraints (Isler et al., 2020; Isler & Yilmaz, 2022), we choose to address this matter by employing time pressure manipulation, as it is the most commonly used cognitive manipulation in the studies regarding the cognitive basis of prosociality (Capraro, 2023; Kvarven et al., 2020). Furthermore, we believe it best replicates real-world situations, such as workplace scenarios, which is more beneficial for further practical application. In our everyday lives, quick decision-making in risky and uncertain situations is prevalent (Olschewski & Rieskamp, 2021), and we frequently engage in recurrent interactions with others over a period of time (Nishi et al., 2016). Taking these aspects into consideration, understanding how time pressure affects the decision to cooperate in one-shot and repeated interactions under risk and

uncertainty is an essential topic of concern from a practical and theoretical point of view (Jarke-Neuert & Lohse, 2022; Olschewski & Rieskamp, 2021).

As previously reviewed, most experimental studies that analyze the effects of intuition and deliberation on cooperation and prosocial behavior have primarily applied tasks in which it is certain how our decisions affect our own outcomes and the outcomes of others (Jarke-Neuert & Lohse, 2022). Therefore, in this dissertation, we aimed to explore these effects using time pressure manipulation in the context of cooperative and prosocial behavior under situations of uncertainty. To the best of our knowledge, this research also provides pertinent insights regarding the SHH in domains where it has not been fully comprehended yet.

In the first experiment reported in Chapter 2, we empirically investigate the effect of manipulating decision times in a repeated prisoner's dilemma with and without outcome uncertainty. Our main aim in this first study was to understand the effect of outcome uncertainty on cooperative behaviors in a repeated game when individuals were under time pressure manipulation. To this end, we conducted a study with four conditions to analyze the effect of inducing time pressure or time delay when participants play a repeated determinist or a stochastic PD game. Contrary to previous research, we did not find that participants cooperate less under a stochastic version of the game. The lack of effect may be due to this study's manipulation of decision time. Consistent with previous literature, we observed a learning effect across the game, with participants becoming less cooperative across rounds. We found that participants exhibited higher levels of cooperation in the first 50 rounds when there was time pressure compared to a time delay condition. Nevertheless, this effect was not maintained throughout the experiment's full duration. This result seems consistent with the idea that time pressure positively affects cooperation in a more cooperative environment. However, time pressure did not have an effect in a less cooperative environment. In addition, our results appear to suggest that participants cooperate more at the beginning of every new interaction, particularly under a time-pressure condition.

In the next chapter of the dissertation (Chapter 3), two additional laboratory experiments were conducted to expand on our previous findings and address the limitations identified in the first study. Specifically, we noticed that the first study lacked a forced time delay condition, resulting in quicker reaction times in a deliberation condition. A lack of understanding of the game's structure could also have influenced our results since we did not assess individuals' game comprehension. In this matter, in the second study, we sought to overcome these limitations and directly test the hypothesis of the SHH by conducting an experiment exploring the effects of uncertainty in a one-shot game. Through this study, we aimed to further contribute to the theoretical understanding of framing social dilemmas with and without

uncertainty in the context of gains vs. losses. We anticipated that implementing these changes in the context of the game from the first study to the second would lead to higher cooperation rates, specifically by confirming participants' understanding of the game and introducing a gain frame in the PD (Everett et al., 2017; Isler et al.,2021; Isler et al., 2018; Strømland et al., 2018).

In the first experiment of Chapter 3, participants played a one-shot game involving either a stochastic or a deterministic prisoner's dilemma and a gain or loss frame. In the second experiment, we conducted a repeated game to strengthen the effects observed in the first experiment and analyze the impact of learning on participants' behavior. In line with the SHH, both experiments showed that decisions made under time pressure tended to be more cooperative. Specifically, results suggested that time pressure augments cooperation in different contexts, including situations of uncertainty and loss frames. In the repeated version of the game, results also suggested that cooperation decreases as the experiment progresses, suggesting a learning process. Despite the overall negative trend, there was a seasonality effect, with cooperation in the initial round of each supergame being higher than in subsequent rounds. This effect was even more significant under time pressure, suggesting an initial intuitive propensity. There was also a slower decay rate of cooperation in the stochastic condition compared to the deterministic, suggesting a slower learning process in stochastic games. Furthermore, our data also suggests that participants relied more on their past decisions when they had more reasoning time.

In Chapter 4, we intended to investigate whether the SHH effects were limited to social dilemmas. To achieve this, we replicated previous findings by manipulating time under COVID-19 uncertainty. Therefore, we conducted an online study framed as a practical implementation of cooperation under uncertainty within the context of COVID-19. In this study, participants were presented with one of four hypothetical decisions concerning the threat of being infected with COVID-19 infectious disease. We manipulated the level of uncertainty in the hypothetical decision by modifying the information received regarding the vulnerability of individuals that participants could potentially transmit COVID-19 if they decided to go to work. In the scenario presented, participants had to choose the likelihood of staying at home - prosocial intention - or going to work. In addition, each participant was randomly assigned to either a time pressure condition (i.e., participants were required to decide quickly) or a time delay condition (i.e., there is no time limit to decide). Overall, our results suggested that the likelihood of staying home - prosocial behavior- was higher in participants under time pressure than under time delay. Additionally, we demonstrated that uncertainty does not necessarily reduce prosocial behavior.

After reviewing the literature regarding the topics under study and providing a concise overview of all the experiments conducted, the following chapters (Chapters 2-4) will examine each study in more

detail. In the concluding section of the dissertation (Chapter 5), we will then present a general discussion on the overall contribution of the studies conducted.

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CHAPTER 2

Empirical Study 1:

A Dual-Process Approach to Cooperative Decision-Making Under Uncertainty

2. A Dual-Process Approach to Cooperative Decision-Making Under Uncertainty

This empirical work was adapted from the published work in the Journal of PLoS ONE.

Note that it was published under the Chicago style but revised to the APA style 7th Edition for the dissertation.

Reference:

Costa, D., Arantes, J., & Keating, J. (2022). A dual-process approach to cooperative decision-making under uncertainty. *PLoS ONE, 17*(3), Article e0265759. https://doi.org/10.1371/journal.pone.0265759

In addition, results from this empirical work were partially or fully presented in five scientific events:

At the 2019 Summer School of the Swiss Graduate School for Cognition, Learning, and Memory, organized by the University of Bern (Weggis, Switzerland). The topic was: Dealing with uncertainty: Decision-making and memory processes.

Costa, D., Arantes, J., & Keating, J. (2019, November 15-18). *How do we cooperate under uncertainty: A dual-process perspective* [Poster presentation]. 40th Annual Conference of the Society for Judgment and Decision Making (SJDM). Montreal, Canada

Costa, D., Arantes, J., & Keating, J. (2020, June-September). *A dual-process approach to cooperative decision-making under uncertainty* [Poster presentation]. APS Virtual Poster Showcase. Online, United States

Costa, D., Arantes, J., & Keating, J. (2021, April 9-10). *A dual-process approach to cooperative decision-making under uncertainty* [Blitz talk]. 15º Encontro Nacional da Associação Portuguesa de Psicologia Experimental [15th National Meeting of the Portuguese Association of Experimental Psychology]. Online, Portugal

Costa, D., Fernandes, N., Arantes, J., & Keating, J. (2022, May 5-7). *The cognitive basis of cooperative decision-making: Experiments on uncertainty, frames, and time constraints* [Conference presentation]. First Joint International APPE-SEPEX Metting. Faro, Portugal.

Supplemental materials with instructions and additional analyses can be found in Appendix A.

2.1. Abstract

Cooperative behaviors are typically investigated using social dilemmas inserted into scenarios with well-known characteristics. Nonetheless, in real life, group members may be uncertain about what others will decide (social uncertainty) and the characteristics of the dilemma itself (environmental uncertainty). Previous studies have shown that uncertainty reduces the willingness to cooperate. Dual-process approaches to cooperation have given rise to two different views. Some authors argue that deliberation is needed to overrule selfish motives, whereas others argue that intuition favors cooperation. In this work, our goal was to investigate the role of intuitive mental processing on cooperation in a prisoner's dilemma game involving uncertainty.

Our results showed that participants cooperated less with their counterparts as the number of rounds progressed, suggesting a learning process and that intuitive mental processing in the first 50 rounds appears to favor cooperation under both deterministic and stochastic conditions. These results may help clarify the literature's mixed effects regarding cognitive processing manipulation on cooperation. Developing a better understanding of these effects may improve strategies in social problems involving cooperation under uncertainty and cognitive constraints.

Keywords: cooperation; dual-process models; intuition; prisoner's dilemma; uncertainty;

2.2. Introduction

Cooperative behaviors are defined as actions in which individuals benefit another individual or group of individuals while having a personal cost to themselves (Rand & Nowak, 2013). These behaviors have existed since the days of our hunter-gatherer ancestors, demonstrated through various actions such as joint living, cooperative hunting, and sharing resources, all of which are necessary for their survival (Fehr & Fischbacher, 2003). Cooperation continued to change and evolve within small and large societies throughout the centuries, giving to the human species an enormous evolutionary gain (Fehr & Fischbacher, 2003). Still, generalized cooperation remains one of the greatest unresolved mysteries in the evolution of our species (Axelrod, 1984; Fehr & Fischbacher, 2004). While many individuals recycle, give blood, pay taxes, vote, and donate to charitable foundations in the modern world, not all individuals choose to cooperate (Alós-Ferrer & Garagnani, 2020). Thus, the question emerges: why do some individuals cooperate while others do not?

Several mechanisms have been proposed to explain cooperation (Nowak, 2006, 2012), such as (i) kin selection (helping relatives; Hamilton, 1964); (ii) direct reciprocity (trading favors; Trivers, 1971); (iii) indirect reciprocity (maintaining a good reputation; Nowak & Sigmund, 1998, 2005); (iv) special selection (clusters of cooperators outcompete defectors; Nowak & May, 1992; Ohtsuki et al., 2006); (v) multilevel selection (competition is not only between individuals but also between groups; Traulsen & Nowak, 2006); and (vi) enforced cooperation (mechanism for rewarding cooperators or punishing defectors (Fehr & Fischbacher, 2004; West et al., 2007).

Cooperative behavior has mainly been investigated using social dilemmas (Dawes & Messick, 2000; Kollock,1998; van Lange et al., 2013). In the beginning, social dilemmas were characterized by two essential properties (Dawes, 1980): (i) each individual gets a higher payoff if they decide to defect, independently of what the other individuals choose, and (ii) all individuals receive a lower outcome if all defect rather than if all cooperate (Dawes, 1980). Later, social dilemmas were defined as interdependence situations characterized by a conflict between immediate self-interest and long-term collective interest (van Lange et al., 2013).

Researchers have studied social dilemmas from different disciplines and used different methodologies to understand cooperation (Capraro, 2013). Two of the most prominent and highly used social dilemmas (Axelrod & Hamilton, 1981; Taylor, 1976, 1987) are the Prisoner's Dilemma (PD) and the Public Goods Game (PGG). For example, in the PGG dilemma, all members may benefit regardless of whether they contributed to the good (Capraro, 2013). The PD has received much attention throughout the years and has become a leading paradigm for exploring cooperative decision-making (Axelrod &

Hamilton, 1981; Gracia-Lázaro et al., 2012; Wang et al., 2012). Specifically, this game involves two players, and each player needs to choose between two strategies: cooperation (C) or defection (D - see Table 2). The relative value of the four possible outcomes defines this game (Axelrod & Hamilton, 1981; Kollock, 1998). Both players will receive a reward (*R)* if both cooperate and a punishment (*P*) if both choose to defect. However, when a defector meets a cooperator, they exploit the cooperator and receive the temptation (*T)*, and the cooperator is left with the sucker's payoff (*S)*. In the prisoner's dilemma game, the outcomes should have the following relationship: T > R > P > S (Rapoport & Chammah, 1965; Wang et al., 2012). Even though it is individually optimal to defect (no matter what the other does), the optimal result, assuming none of the parties is willing to be exploited, requires both parties to cooperate (Axelrod & Hamilton, 1981; Wang et al., 2012).

Table 2

Payoff Matrix of a Prisoner's Dilemma (PD) Game

		Player 2	
		C	D
Player 1	C	R, R	S, T
	D	T, S	P, P

These social dilemmas have been used to model human behavior in social dilemmas like pollution control, intergroup conflict, or the depletion of natural resources (Capraro, 2013).

2.2.1. Cooperation Under Uncertainty

In most social dilemma experiments, the dilemma's characteristics (e.g., the payoff matrix, the number of iterations, and the number of participants) are usually known by all members with certainty (van Dijk et al., 2004). However, such defining characteristics are not always evident in real-life situations. For example, several alternative strategies may be available in real-life situations, and the outcome of interactions may be uncertain (Gangadharan et al., 2009). Such uncertainty may be fractioned into two distinct constructs: risk (i.e., the probability of outcomes is known) and ambiguity (i.e., the probability of outcomes is unknown; Vives & FeldmanHall, 2018). In uncertain social dilemmas, members of a group may be unsure about what the other players will decide (i.e., social uncertainty), as well as the characteristics of the dilemma (i.e., environmental uncertainty (Messick et al., 1988; van Dijk et al., 2004). Several studies have shown that environmental and social uncertainty reduces the individuals' willingness to cooperate in various social dilemmas (Budescu et al., 1990; Gustafsson et al., 1999; van Dijk et al., 2004; van Lange et al., 2013). In fact, individuals tend to avoid uncertainty both within social

(FeldmanHall & Shenhav, 2019) and non-social domains (Tversky & Shafir, 1992; van Dijk & Zeelenberg, 2003).

Nonetheless, some studies have shown that if the uncertainty is lowered, providing participants with some feedback regarding how their counterparts responded in the previous trial, their willingness to cooperate might increase (Jorgenson & Papciak, 1981; Sniezek et al., 1990). If individuals find that their counterparts cooperate with them, they will also be more willing to cooperate. Conversely, if their counterparts did not cooperate, they will become less motivated to cooperate in subsequent trials (van Dijk et al., 2004; Wilke & Braspenning, 1989). A recent framework explains that humans, to reduce social uncertainty, tend to use three interrelated mechanisms (FeldmanHall & Shenhav, 2019): i) *automatic inferential processes* like the formation of impressions that rapidly and with little effort slight individuals predictions using past knowledge and contextual cues for reducing the uncertainty of how the other person might think and behave; ii) more *controlled inferential processes* that additionally adjust these automatic predictions through a mental representation of the other person's thoughts and feelings; and iii) *learning processes* that revise one's predictions based on feedback.

Several studies have investigated how different types of environmental uncertainty (e.g., resource size uncertainty, group size uncertainty) influence cooperation (van Dijk et al., 2004). For instance, resource size uncertainty (i.e., the payoff matrix) decreases the overall cooperation rate (van Dijk et al., 2004). Indeed, previous studies have observed that participants tend to: (i) overestimate the resource pool's size; (ii) increase their requests and overharvest and also expect others to increase their requests (Budescu et al., 1995; Gustafsson et al., 1999; Hine & Gifford, 1996; Rapoport et al., 1992; Suleiman et al., 1999); and (iii) there is an enhance of the between-participant variance (Suleiman et al., 1999; van Dijk et al., 2004).

Additionally, Gong et al. (2009, 2013) examined the degree of cooperation both in individuals and groups under resource size uncertainty using two versions of the PD: one Stochastic Prisoner's Dilemma (SPD) and one Deterministic Prisoner's Dilemma (DPD). On the SPD, the outcomes of strategies are uncertain with known probabilistic outcomes. Each player knows that cooperation without their opponent's corresponding cooperation exposes them to losses with defined probabilities. The related deterministic game is obtained by replacing the stochastic game's probabilistic outcomes with the expected values (value x corresponding probability). Although groups are less cooperative than individuals in the DPD game, a reversed effect was observed when uncertainty was present. Groups were more cooperative in SPD games than individuals (Gong et al., 2009). The authors report a learning process in their study as participants repeatedly played a game with feedback. The data showed that participants

tended not to cooperate as the number of rounds and supergames increased. Other studies also report that cooperation significantly decreased over time under repeated games with feedback (Fehr & Fischbacher, 2003; Jordan et al., 2013).

Considering now another type of environmental uncertainty, group size, previous studies have shown a more positive effect on cooperation (Au & Ngai, 2003; Boosey et al., 2017; De Kwaadsteniet et al., 2008). This type of uncertainty leads to more contributions in resource dilemmas (De Kwaadsteniet et al., 2008) and decreases over-harvesting compared to group size certainty (Au & Ngai, 2003). In a recent study, the authors manipulated the group size under linear public good games and found that uncertainty/risk positively affected conditional cooperation (Mill & Theelen, 2019). Even though many researchers have explored the influence of uncertainty on social decision-making, this topic remains poorly understood (Vives & FeldmanHall, 2018). Moreover, research still needs to explain why and how cooperation decreases in some types of social and environmental uncertainty. Thus, to better understand the influence of risk and uncertainty on cooperation, more studies should be developed to identify how uncertainty constructs and cognitive mechanisms influence cooperation (Vives & FeldmanHall, 2018).

2.2.2. A Dual-Process Approach to Cooperation

The cognitive mechanisms underlying cooperative behavior are explored in the literature by applying dual-process models, which conceptualize decisions as arising from a competition between intuitive ("automatic") versus deliberative ("controlled") cognitive processes (Kahneman, 2011). Knowledge of dual-process theories has increased over recent years (Capraro, 2019; De Neys, 2021; De Neys & Pennycook, 2019; Evans & Stanovich, 2013; Kahneman, 2011; Pennycook et al., 2018). One of the models developed assumed two types of processes: Type 1 and Type 2 (Evans & Stanovich, 2013). Type 1 processing is characterized by having autonomy – it does not require "controlled attention." Autonomous processes tend to be fast, automatic, nonconscious, independent of cognitive ability, experience-based decision-making, and do not put a heavy load on central processing capacity (Evans & Stanovich, 2013). In this definition, Type 1 processes give rise to intuitions (Evans, 2010; Kahneman, 2003). In Type 2 processing, responses rely on hypothetical thinking and working memory. This type of response is slow, conscious, sequential, consequential decision-making and correlated with cognitive ability (Evans & Stanovich, 2013).

Researchers have manipulated cognitive processes using time constraints methods (Capraro, 2019; Rand, 2016; Rand et al., 2012). For example, to promote Type 1 processing, participants reply in a given time window ("time pressure" condition). In contrast, to facilitate Type 2 processing, participants

may think carefully for some time over the decision problem before deciding ("time delay" condition; Capraro, 2019; Rand, 2016; Rand et al., 2012). The seminal study regarding decision time and cooperation revealed that time pressure manipulation increases cooperative behavior relative to the time delay in the one-shot public goods game (Rand et al., 2012). Subsequent studies went on to replicate these findings and found that this effect increases significantly amongst inexperienced and trusting participants compared with individuals experienced in experimental economic games (Rand & Kraft-Todd, 2014; Rand et al., 2014). This observation led to the development of a theory that predicts when intuition will and will not influence cooperation – The Social Heuristics Hypothesis (SHH) (Bear & Rand, 2016; Rand et al., 2014). According to the SHH, "*people internalize strategies that are typically advantageous and successful in their daily social interactions*" (Rand et al., 2014). Researchers have distinguished between pure and strategic cooperation to understand better the SHH effects (Capraro, 2019; Rand, 2016). Pure cooperation refers to situations where defection is always payoff maximizing, regardless of the other person's decision (e.g., one-shot prisoner's dilemma). On the other hand, strategic cooperation refers to how cooperation or defection can maximize the payoff, depending on the other players' decisions (Capraro, 2019; Rand, 2016). In repeated interactions (e.g., repeated PD), cooperation can be payoff-maximizing as long as the other players' reputation is known and the possibility of reciprocation exists (Jordan et al., 2015; Peysakhovich & Rand, 2016). If deliberation favors payoff-maximizing responses, then promoting deliberation should only reduce cooperation when defection is the payoff-maximizing choice. Therefore, intuition should favor cooperation when defection is payoff-maximizing, while deliberation should favor defection (Rand, 2016). The SHH assumes that over time, strategies that are typically successful become the default response (Rand, 2016). Thus, individuals who generally interact in environments where cooperation is advantageous should be predisposed to cooperate even if, on occasion, this does not maximize outcomes: they have internalized a cooperative strategy (Capraro & Cococcioni, 2015; Jordan et al., 2015; Rand, 2016; Rand & Kraft-Todd, 2014). On the other hand, deliberation adapts the behavior into the most favorable strategy for a given situation (Rand et al., 2014). Thus, deliberative responses tend to be less cooperative than intuitive responses in interactions where defection is the optimum strategy (Rand, 2016). Several subsequent studies using PGG have obtained results consistent with the seminal work, revealing a positive effect of time pressure on cooperation (Isler et al., 2018). Moreover, this result was found even when the game is played with outgroup members (Everett et al., 2017; Rand et al., 2015) and in competitive public goods games (Cone & Rand, 2014).

Other studies using PD and PGG found the opposite effect of time pressure on cooperation (Capraro & Cococcioni, 2016; Goeschl & Lohse, 2018; Lohse, 2016). Furthermore, several studies have

also failed to find the effect of time pressure on cooperation (Bouwmeester et al., 2017; Tinghög et al., 2013; Verkoeijen & Bouwmeester, 2014). Moreover, several recent studies have found that individual factors have a moderator effect on time pressure on cooperation. For example, a recent study found no overall effect of time pressure on cooperation in both one-shot and repeated PGG; however, they found that time constraints interact with two individual characteristics: Social Value Orientation and Strategic Uncertainty (Alós-Ferrer & Garagnani, 2020). Additionally, while exploring the moderating effect of individual risk factors (integrating measures of individual dominance, self-control, and self-construal), a recent study found that time pressure increases cooperation, but only among low-risk propensity men (Bird et al., 2019). However, the effect reverses among high-risk propensity men (Bird et al., 2019).

Contrary to previous findings that cooperation is faster than defection, or vice versa, a study has shown that reciprocal decisions occur more quickly in repeated interactions (Nishi et al., 2016). Furthermore, the authors show that cooperation is faster than defection in cooperative social environments, while defection is faster than cooperation in non-cooperative environments. The result found can be explained because, in repeated games, people are greatly affected by the previous actions of the other individuals they are playing with (Dal Bó & Fréchette, 2011; Fudenberg et al., 2012). However, in the study, the authors also evaluate the situation when participants do not know the decision of their interaction partners (e.g., in an unknown environment). In this situation, the decision times are similar to those in the cooperative environment – cooperation is faster than defection (Nishi et al., 2016). Results from the unknown environment are consistent with the idea of the SHH that participants' frequent interactions with cooperative institutions caused them to expect others to cooperate and to want to cooperate themselves (Nishi et al., 2016).

Rand (2016) conducted a meta-analysis where they found evidence supporting the SHH's prediction that intuition increases cooperation in games where non-cooperation was strictly payoff-maximizing (Rand, 2016). On the other hand, results found that intuition does not affect games where cooperation could be payoff-maximizing (e.g., games in which reciprocity was possible; Rand, 2016). Moreover, a recent meta-analysis found that the effect of intuition on cooperation was driven by conceptual primes explicitly asking people to rely on their emotions (Kvarven et al., 2020).

2.2.3. The Present Study

The present study aims to empirically investigate the cognitive mechanisms of human cooperation by analyzing the impact of intuition on individual cooperation under uncertainty. Given that this is a new research field and that the uncertainty present in our lives can affect our judgments and

decisions studying these two variables – cognitive mechanisms of cooperation and uncertainty- becomes essential. Additionally, observing the choices of subjects over time is crucial once real-life situations are often characterized by repeated interactions (Rand & Nowak, 2013). Furthermore, extending research on decision time to repeated games may explain the mixed results found in the literature and may help to clarify the relationship between decision time and cooperation (Capraro, 2019; Nishi et al., 2016; Nishi et al., 2017). Specifically, in this study, we will examine how rates of cooperation change 1) during the repeated prisoner's dilemma and 2) between different combinations of time pressure and uncertainty.

Following previous observations regarding the decrease in cooperation in the repeated prisoner's dilemma (Gong et al., 2009), we expect cooperation to decrease over time in our first hypothesis. Given this pattern of cooperation rates and the findings in games with repeated interactions (Nishi et al., 2016) in our second hypothesis, we expect that time pressure manipulation will favor cooperation in the first interactions since we expect a more cooperative environment in the beginning. On the contrary, in our third hypothesis, we expect that time pressure manipulation will not affect cooperation as the game progresses. Additionally, we aim to understand the effect of the manipulation of uncertainty on individual cooperation, considering that previous findings on uncertainty stated that uncertainty reduces the willingness to cooperate (Gong et al., 2009; van Dijk et al., 2004). Therefore, our fourth hypothesis is that cooperation will be higher in the deterministic version of the PD, and individuals will be less cooperative in the stochastic version of the game (when uncertainty is present). To extend the knowledge in this field, we also aim to understand the relationship between uncertainty and time pressure manipulation since cooperative behavior diminishes under environmental uncertainty situations (Gong et al., 2009) and under time delay (Rand, 2016; Rand et al., 2014). However, when adding a time delay, cooperative behavior will decrease under conditions of uncertainty. Therefore, we hypothesized that time pressure manipulation augments cooperative behavior under conditions of uncertainty.

2.3. Method

2.3.1. Participants

A power analysis using the G*Power computer program (version 3.1; Faul et al., 2009) indicated that a total sample of 108 participants would be needed to detect significant effects of the uncertainty effect with 80% power using a z-test with a binomial distribution and alpha .05. Therefore, our sample comprised a total of 112 university students (88 women), ranging between 17 and 44 years of age (M = 21.90, SD = 4.83). Participants belonged to the University of Minho, with 107 psychology students. Regarding the year of the degree they are attending, sixty-nine participants (61.6%) reported being in a

bachelor's degree, forty-seven participants (25.0%) report being in the master's, and fifteen participants (13.4%) report being in the first year of a doctoral degree or doing a postgraduation. From the total number of participants, one hundred four participants (92.9%) were Portuguese, five Brazilian, two Spanish, and one British. However, all students report living and studying in Portugal. Thirty-three participants (29.5%) reported a medium-low socio-economic value, sixty-four participants (57.1%) reported a medium value and fifteen (13.4%) reported a medium-high socio-economic value. All participants gave their written informed consent, according to the Helsinki Declaration. The Ethics Committee for Research in Social and Human Sciences of the University of Minho approved the study. There were no exclusion criteria. Participants were naive concerning the whole experimental procedure (they believed they were playing a problem-solving experiment), and the majority received credit courses for their involvement. Two participants were randomly chosen to receive a prize using the same procedure as Gong et al. (2009); however, instead of money, participants received a shopping voucher proportional to the points gained in the experiment.

2.3.2. Materials

2.3.2.1. Sociodemographic Questionnaire. Participants answered questions regarding age, gender, nationality, socio-economic status (SES), and university degree level.

2.3.2.2. Balloon Analogue Risk Task (BART; Pleskac & Wershbale, 2014). This task measures risk-taking propensity and comprises 30 balloon trials. In this task, the computer screen showed: i) a computerized balloon; ii) the number of pumps on that balloon; iii) a second display listing the points earned on that balloon, labeled "*Points so far in this balloon*"; and iv) a permanent points-earned display, labeled "*Total Points*", that added up the points scored on the 30 balloons presented. Each time participants pressed the e key on the keyboard, the balloon could increase, and consequently, participants would earn 10 points. After pressing the "e" key as many times as participants wanted, they must press the "p" key on the keyboard to stop and collect the points. However, the balloon could explode when participants were pressing the key for a pump, and consequently, participants would lose all the points earned on that trial. After each trial, a fixation cross appeared on the center of the screen for 1s, and the subsequent balloon trial began. The likelihood that a balloon would explode ensured that, on average, the optimal number of pumps in each trial was 64. The explosion of the balloon follows the methodology described by Pleskac and Wershbale (2014): "*Briefly, 15 integers between 1 and 128 were randomly generated. These random numbers determined the explosion points for 15 balloon trials. The explosion points for the remaining 15 balloon trials were set equal to 128 - X + 1 where X was the vector*

of 15 randomly generated '' (Pleskac & Wershbale, 2014, p. 146). Before starting the task, participants played one practice trial to confirm they comprehended the instructions.

2.3.2.3. Big Five Inventory (BFI; John & Srivastava, 1999; Portuguese version adapted by Brito-Costa et al., 2015). This instrument assesses personality traits in five dimensions: agreeableness, conscientiousness, extroversion, neuroticism, and openness to experience. It comprises 44 easy-to-understand short sentences, each referring to only one of the Big Five personality dimensions. Participants indicate the extent to which each trait applies to themselves (e.g., ''*I see myself as someone who tends to be lazy*''), using a 5-point scale ranging from 1, ''*Strongly disagree*'' to 5 ''*Strongly agree*''. The BFI has good internal reliability (for the total 44 items, Cronbach's α = .78; Brito-Costa et al., 2015).

2.3.2.4. Interpersonal Reactivity Index (IRI; Davis, 1983; Portuguese version adapted by Limpo et al., 2010). This instrument assesses empathy and comprises 24 statements about feelings and thoughts that the person may or may not have experienced. The instrument contains four subscales, each with six statements: Perspective Taking (PT), Empathic Concern (EC), Personal Discomfort (PD), and Fantasy (F). Participants indicate, for each statement, the extent to which it applies to themselves (e.g., '' *I often have tender, concerned feelings for people less fortunate than me*'') on a 5-point Likert scale, from 0, *''It does not describe me well''*, to 4, ''*Describes me very well*''. The translation and validation study to the Portuguese population confirmed the adequate internal consistency and good reliability of this instrument in the assessment of empathy (PT Cronbach's α = 0.73; EC Cronbach's α = 0.76; PD Cronbach's α = 0.80; F Cronbach's α = 0.84) (Limpo et al., 2010).

2.3.2.5. Short-Form of the Positive and Negative Affect Schedule (PANAS – SF; Watson et al., 1988; Portuguese version adapted by Galinha et al., 2014). This scale measures positive and negative affect and assesses the participants' current mood state. It includes five adjectives covering positive mood (e.g., ''*excited*,'' ''inspired'') and five adjectives covering negative mood states (e.g., ''*nervous*,'' ''*guilty*''). Participants are asked to show to what extent, at the time of the response, they feel the emotion represented in each item on a 5-point Likert scale ranging from 1, ''Very little or nothing'', to 5 ''Extremely''. This instrument presents good internal reliability (Cronbach's α = 0.86 for positive affect, 0.89 for negative; Galinha et al., 2014).

2.3.2.6. Game-Related Questionnaire. Participants were asked an open question regarding their strategy during the game. They were also asked to indicate to what extent they were close to the other participants and how much they cooperated (with the other participants present in the game) in their daily life on a 7-point Likert scale, from 1, *''Very little or nothing''* to 7, ''*Extremely*''. Also, participants were asked four questions regarding the execution of the task: (a) how pleasant it was (1= "*Extremely*

pleasant" to 7 = "*Extremely unpleasant*"); (b) how stressful it was (1 ="*Extremely stressful*" to 7 ="*Very little or nothing*"); (c) how difficult it was (1= *"Not difficult at all"* to 7 ="*Very difficult*"; and (d) how well they understood both the instructions and the task (1=*"Very little or nothing"* to 7 ="*Extremely*").

2.3.3. Procedure

The study was conducted in the behavioral and human cognition laboratory of the School of Psychology at the University of Minho. Participants arrived at the laboratory in groups of four and were randomly assigned to one condition. More specifically, participants were divided into four conditions in a 2 (game type: Deterministic Prisoner's Dilemma [DPD] vs. Stochastic Prisoner's Dilemma [SPD]) × 2 (decision time: time delay vs. time constraint) between-subject design. Each participant used one computer to make their decisions. Computers were placed in the experimental room and in separate stations enclosed by cubicle dividers to provide anonymity. Participants were approximately 150 cm apart from each other. The informed consent was presented first, followed by the sociodemographic questionnaire and the Positive and Negative Affect Schedule (PANAS-SF) for all participants, and then participants played the game task. At the end of the game task, they answered the game-related questionnaire, the PANAS-SF, and completed the Balloon Analogue Risk Task (BART). Finally, participants answered the Big Five Inventory and the Interpersonal Reactivity Index (IRI) presented in a counterbalanced order.

During the game phase, initially, participants received instructions regarding the structure and rules of the game on the computer screen. The structure of the game participants learned differed according to the condition they were attending. On the SPD, the outcomes of alternative strategies were uncertain (see Table 2). Each player knew that cooperation (i.e., to invest in a risk-reducing measure) without the corresponding cooperation from their opponent (the participant present in the room that they will play against) would define the probabilities of losses. By removing the uncertainty and replacing the values and probabilities in the SPD with the expected values (value x the corresponding probability) (see Table 3), the corresponding DPD was obtained (see Table 4)[3]. The values used in the two games were similar to those in a previous study (Gong et al., 2009).

[3] Due to a program error the SPD and the DPD did not have the same expected value since the situation NOT INVEST – INVEST had different values. The expected value for participants in DPD was (1* -60= -60) and for participants in SPD was (0.20*- 145+0.80*- 45 = -65). Nevertheless, this did not change the structure of a prisoner's dilemma: T>R>P>S, and the R>(S+T)/2.

Table 3

Possible Outcomes in the Stochastic Prisoner's Dilemma Game

		Player 2	
		Invest	Not Invest
Player 1	Invest	-45; -45	20% lose 145, 80% lose 45; 40% lose 100, 60% lose 0
	Not Invest	40% lose 100, 60% lose 0; 20% lose 145, 80% lose 45	52% lose 100, 48% lose 0; 52% lose 100, 48% lose 0

Table 4

Possible Outcomes in the Deterministic Prisoner's Dilemma Game

		Player 2	
		Invest	Not Invest
Player 1	Invest	-45; -45	-60; -40
	Not Invest	-40; -60	-52; -52

Consistent with previous research, we called each sequence of ten rounds played with the same partner a supergame (Gong et al., 2009). Participants played ten supergames of ten rounds each, totaling 100 decisions (the number of supergames was not disclosed to prevent end effects). Participants played against the same player in each supergame and then randomly switched players in the next supergame. At the start of each supergame, each player was given 1500 points, which they used in the game to decide if they wanted to invest or not. The game was described in a loss frame where participants incur a cost to make an investment decision. Each participant decided whether to invest the initial 1500 points to avoid a more significant financial loss.

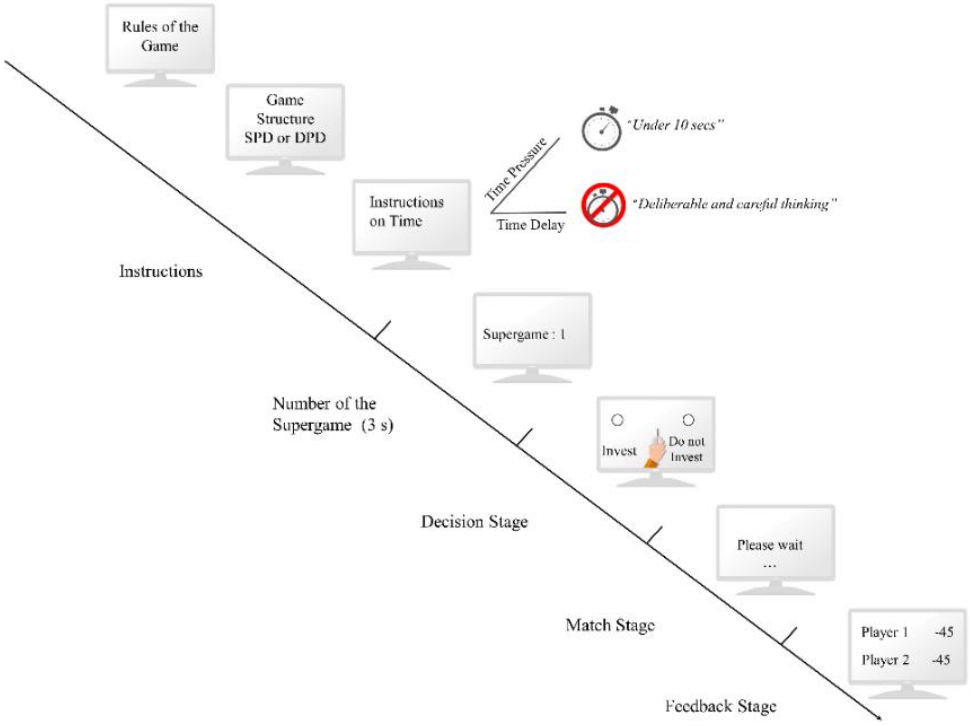
Before initiating the game task, participants received instructions regarding their experimental condition– time delay or time pressure (Rand et al., 2012). In the time pressure condition, participants were asked to make each decision as quickly as possible and were told they could not take longer than 10 seconds. In this condition, a timer appears on the screen to show the time left to decide, and in the last 3 seconds, the timer number is displayed in red. Still, participants could respond after 10 seconds, and the clock showed a warning that the time had ended. On the other hand, in the time delay condition, participants were asked to consider their decision carefully and were asked not to decide for at least 10 seconds (no timer appeared, and they could choose at any moment).

Then, participants see the number of the super game they would play during 3 seconds on the screen. When the decision screen appeared, participants saw the game structure (congruent with their condition) and the following instructions (similar to Gong et al., 2009): "*The other player is also making*

a decision now. You will not know their decision until you submit your decision. So please make your investment decision now and submit it." Participants then could decide whether they wanted to invest or not – *decision stage*. After making a decision, participants were asked to wait while the other player was deciding – designated by the *match stage*. After both participants made their decisions, they received information on both decisions and the payoffs – *feedback stage*. Then, a new decision stage would start. For a representation of the procedure, see Figure 1. The game task was approximately 10 minutes in the time pressure condition, whereas it lasted for approximately 25 minutes in the time delay condition.

Figure 1

Representation of the Game Task



The entire session's duration (including all questionnaires) was approximately 45 minutes, depending on the experimental condition participants were assigned. The BART was programmed in E-Prime (Version 2.0; Psychology Software Tools, 2002; Schneider et al., 2002), whereas the game was developed using z-Tree (Version 4.1.11; Fischbacher, 2007), a software for economic experiments.

2.4. Data Analysis

We first assess the effects of uncertainty and time manipulation on participants' likelihood to cooperate in the repeated Prisoner's Dilemma games by conducting four logistic regressions in R (version 3.6.3; R Core Team, 2019)

The logistic regression model analyzed how investment decisions depended on *decision time* and the *type of games* and examined the interaction between uncertainty and *decision time*. In our study, participants made a dichotomic choice (Invest or Not Invest) in each round, and throughout the session, each participant made a total of 100 decisions. We applied the same analysis as previous studies (Gong et al., 2009), a generalized mixed-effect logistic regression model. Two fixed effect variables were included to control the round and supergame order effect, one for round and one for supergame. In addition, a random effect variable (α) was included in the logistic regression to address interdependency among repeated observations, as shown in Equation (1). Specifically, we regressed each decision (1 for Investing, 0 for Not Investing) as the dependent variable on the following independent variables: *type of game* (DPD vs.SPD), *decision time* (time pressure vs. time delay), the interaction of *decision time* and *game type*, round numbers and supergame numbers. The generalized mixed-effect logistic model used in this analysis can be written as:

$$log\left(\frac{p_{ijk}}{1-p_{ijk}}\right) = \beta_0 + \beta_1 Type\ of\ Game_{ijk} + \beta_2 DecisionTime_{ijk} + \beta_3 Type\ of\ Game_{ijk} DecisionTime_{ijk} + \beta_4 SuperGame_j + \beta_5 Round_k + \alpha_i + \varepsilon_{ijk} \quad (5)$$

The equation (5) presented was estimated by applying the lme4 package in R (Bates, 2005; Gong et al., 2009). Additionally, we analyze participants' reaction time across the conditions and the rounds played. Following previous research (Evans et al., 2015), reaction times were log10 transformed to account for a heavily skewed distribution. Finally, we explore whether there were any individual differences across the four conditions. In the Supporting Information files, we included the results and discussion of further analyses exploring the role of individual differences in explaining the average individual cooperation rate (see supplementary notes in Appendix A).

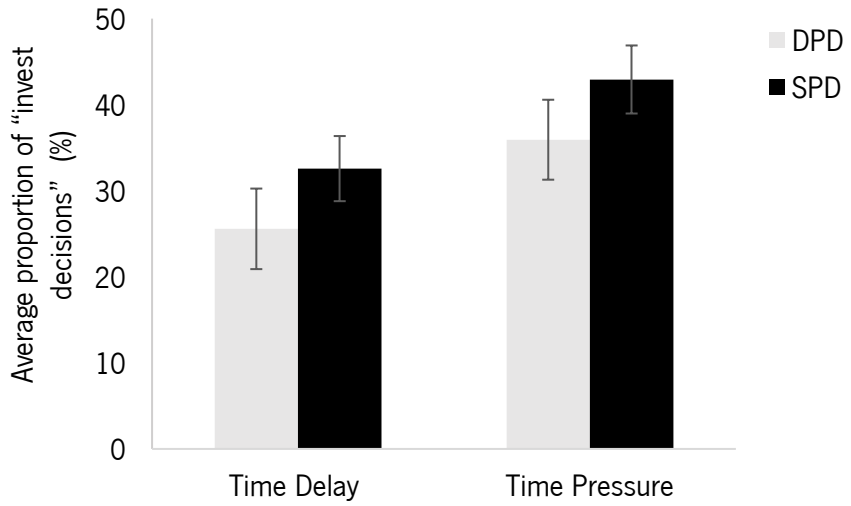
2.5. Results

2.5.1. Logistic Regression Models for the Likelihood of Cooperation in the First 50 Rounds Played

In order to assess the effects of uncertainty and time manipulation on participants' likelihood to cooperate in the repeated PD games, we start by analyzing the first 50 decisions made. Figure 2 shows the average cooperation rate (the proportion of times players invested) from the first 50 decisions. Participants in the time pressure condition appear to cooperate more than the time delay condition. Cooperation rates appear higher in the stochastic prisoner's dilemma in both decision time manipulation.

Figure 2

Cooperation Rates in the Four Conditions Across the First 50 Decisions Participants Made



Note. n = 28 participants in each condition presented. Error bars represent standard errors of the mean.

The model applied revealed a significant effect of time pressure manipulation (β_2 = .75, z = 2.07, p = .039, OR = 2.11, 95% CI [1.04, 4.28]), such that participants were more likely to cooperate under time pressure. However, there was not a significant effect on the type of game played (β_1=.51, z = 1.42, p = .157, OR = 1.67, 95 % CI [.82, 3.39]) or an effect of interaction,(β_3 = .19, z = -.38, p =.704, OR =.82, 95% CI [30, 2.22]). However, the data showed an interesting effect as participants played the game repeatedly (see Table 5 for the analysis with round and supergame as factors). The number of investment decisions decreased significantly as the sequence of supergames advanced (β_4 = -.08, z = -3.52, p < .001, OR=.92, 95% CI [.88, .97]) and with the advance of round within each supergame (β_5 = -.08, z = -7.49, p < .001, OR=.92, 95% CI [.90, .94]).

Table 5

Estimates of the Logistic Regression Model for Cooperation Probability in the First 50 Rounds Played

	β (SE)	*z value*	*p*	95 % CI for odds ratio		
				LL	Odds Ratio	*UL*
Intercept	-.71(.28)					
Type of Game	.52(.36)	1.42	.157	.82	1.67	3.41
Time manipulation	.75(.36)	2.07	.038*	1.04	2.12	4.33
Round 2	-.47(.14)	-3.35	<.001	.48	.63	.82
Round 3	-.44(.14)	-3.14	.002	.49	.65	.85
Round 4	-.60(.14)	-4.27	<.001	.42	.55	.72
Round 5	-.64(.14)	-4.56	<.001	.40	.53	.69
Round 6	-.55(.14)	-3.91	<.001	.44	.58	.76
Round 7	-.68(.14)	-4.84	<.001	.38	.51	.67
Round 8	-.87(.14)	-6.12	<.001	.32	.43	.55
Round 9	-.89(.14)	-6.20	<.001	.31	.41	.55
Round 10	-.94(.14)	-6.54	<.001	.29	.39	.52
Supergame 2	-.01(.10)	-.13	.900	.81	.99	1.20
Supergame 3	-.22(.10)	-2.11	.027	.65	.80	.97
Supergame 4	-.17(.10)	-1.65	.098	.69	.85	1.03
Supergame 5	-.32(.10)	-3.14	.002	.60	.73	.89
Game type x Time manipulation	-.20(.51)	-.40	.689	.30	.81	2.22
AIC	6088.4					
Log-likelihood	-3026.2					
Number of obs.	5600					

Note. β =coefficient; *SE* = standard error of the coefficient; CI- = confidence Interval; *LL* = lower limit; *UL* = upper limit; AIC = The Akaike information criterion.

2.5.2. Logistic Regression Models for the Likelihood of Cooperation in the Last 50 Rounds Played

To compare with the results from the first 50 decisions, we applied a mixed-effects logistic regression model to the last 50 decisions participants made. The model demonstrated no significant effect on the type of game played (β_1 = -.19, z = -.38, p = .707, OR =.83, 95% CI [.30, 2.5]). Additionally, there was no significant effect of the time manipulation (β_2 = -.03, z = -05, p = .961, OR = .98, 95% CI [.35, 2.68]), and there was no interaction effect between the type of game played and the time manipulation (β_3 = .68, z = .95, p = .344, OR =1.98, 95% CI [.48, 8.17]).

However, the data showed a marginally significant effect as participants played the game repeatedly in supergames (β_4 = -.05, z = -1.92, p = .056, OR =.95, 95% CI [.91, 1.00]), the number of investment decisions decreased as the sequence of supergames advanced. Within each supergame, there is a significant effect of the ten rounds played (β_5 = -.11, z = -9.10, p < .001, OR =.89, 95% CI [.87, .92]), implying that participants learned not to cooperate over time within the supergame (for more details of the analysis with round and supergame as factors see Table 6).

Table 6

Estimates of the Logistic Regression Model for Cooperation Probability in the Last 50 Rounds Played

	β (SE)	*z value*	*p*	95 % CI for odds ratio		
				LL	*OR*	*UL*
Intercept	-.85(.36)	-2.21	.027			
Type of Game	-.18(.51)	-.36	.720	.30	.83	2.28
Time manipulation	-.03(.52)	-.05	.956	.35	.97	2.69
Round 2	-.24(.15)	-1.68	.093	.58	.78	1.04
Round 3	-.45(.15)	-2.99	.003	.48	.64	.86
Round 4	-.46(.15)	-3.07	.002	.47	.63	.85
Round 5	-.43(.15)	-2.90	.004	.48	.65	.87
Round 6	-.61(.15)	-4.00	<.001	.41	.54	.73
Round 7	-.60(.14)	-3.99	<.001	.41	.55	.74
Round 8	-.89(.14)	-5.72	<.001	.30	.41	.56
Round 9	-1.03(.16)	-6.52	<.001	.26	.36	.49
Round 10	-1.15(.16)	-7.18	<.001	.23	.31	.43
Supergame 7	.37(.11)	3.36	.001	1.17	1.44	1.79

Supergame 8	.06(.11)	.50	.619	.85	1.06	1.31
Supergame 9	.11(.11)	.96	.336	.90	1.11	1.38
Supergame 10	-.10(.11)	-.88	.377	.73	.91	1.13
Game type x Time manipulation	.68(.73)	.94	.346	.48	1.98	8.24
AIC	5286.0					
Log-likelihood	-2625.0					
Number of obs.	5600					

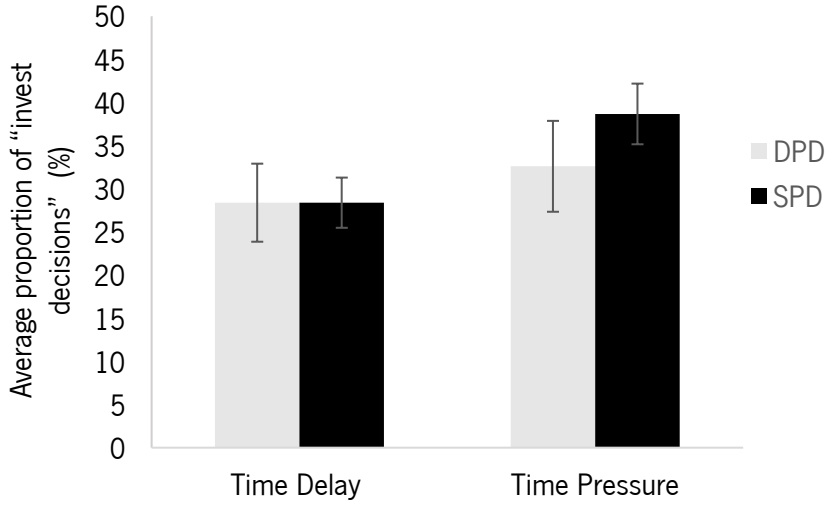
Note. β = coefficient; *SE* = standard error of the coefficient; *CI* = confidence interval; *LL* = lower limit; *UL* = upper limit; AIC= The Akaike information criterion.

2.5.3. Logistic Regression Models for the Likelihood of Cooperation in the 100 Rounds Played

The average cooperation rate (the proportion of times players decided to invest) from the 100 decisions participants made is shown in Figure 3. This figure suggests that participants under time pressure manipulation were more cooperative than under time delay manipulation. Participants in the time pressure condition and who played the SPD game have a higher average proportion of cooperation (*M*=0.39) than the other three conditions. Also, participants in the time-delay condition have a similar average proportion of cooperative responses in the DPD and the SPD (*M*=0.28).

Figure 3

Cooperation Rate Between the Manipulation of Time Pressure and the Type of Game Across All 100 Decisions



Note. *n* = 28 participants in each condition presented. Error bars represent standard errors of the mean.

To confirm these differences, we applied a mixed-effects logistic regression model to a total of 100 decisions participants made. The model demonstrated no significant effect on the type of game played (β_1 = .22, z =.57, p = .572, OR = 1.24, 95% CI [.58, 2.66]). Additionally, there was no significant effect of the time manipulation (β_2 = .47, z = 1.22, p = .224, OR = 1.60, 95% CI [.75, 3.43]), and there was no interaction effect between the type of game played and the time manipulation (β_3 = .06, z = .12, p = *.906, OR =1.07*, 95% CI [.37, 3.11]). The supergame (β_4 = -.05, z = -6.87, p < *.001, OR =.95*, 95% CI [.93, .96]) and round (β_5 = -.09, z = -11.32, p < *.001, OR =.91*, 95% CI [.90, .93]), appeared to follow the same pattern as in the prior model tested. The number of investment decisions decreased significantly as the sequence of supergames advanced and with the advance of rounds within each supergame, implying that participants learned not to cooperate over time (see Table 7 for the analysis with round and supergame as factors and the graphic representation of this tendency in Figure 4).

Table 7

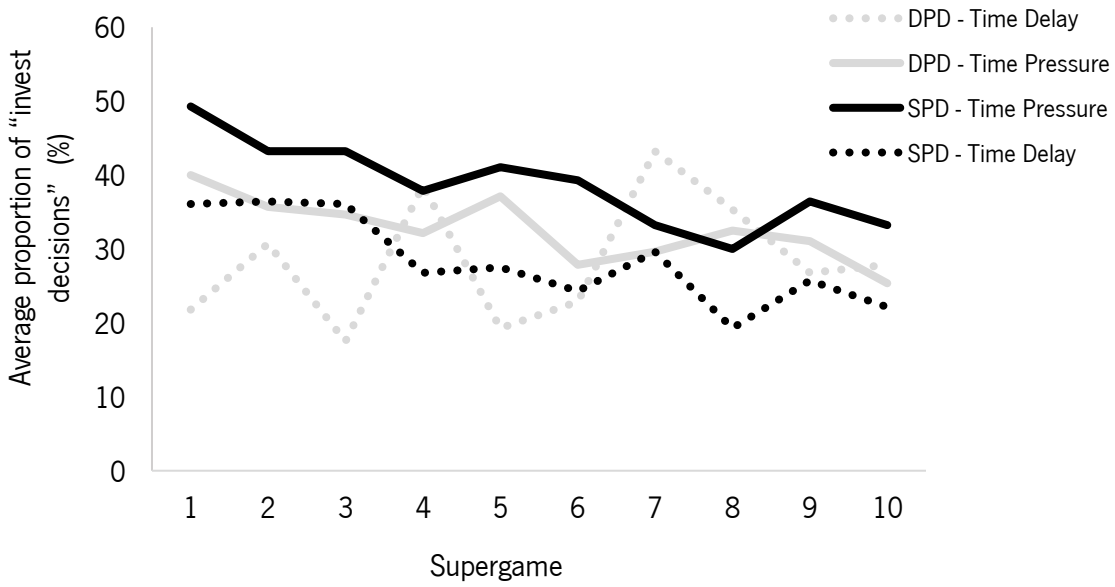
Estimates of the Logistic Regression Model for Cooperation Probability

	β (SE)	*z value*	*p*	95% CI for odds ratio		
				LL	Odds Ratio	*UL*
Intercept	-.53 (.29)					
Type of Game	.22 (.39)	.57	.568	.58	1.25	2.67
Time manipulation	.47 (.39)	1.22	.223	.75	1.61	3.44
Round 2	-.35 (.10)	-3.51	< .001	.58	.71	.86
Round 3	-.42 (.10)	-4.20	< .001	.54	.66	.80
Round 4	-.51 (.10)	-5.07	<.001	.50	.61	.73
Round 5	-.52 (.10)	-5.17	<.001	.49	.60	.73
Round 6	-.54(.10)	-5.42	<.001	.48	.58	.71
Round 7	-.61(.10)	-6.09	<.001	.45	.54	.66
Round 8	-.83(.10)	-8.14	<.001	.36	.43	.53
Round 9	-.90(.10)	-8.71	<.001	.33	.41	.50
Round 10	-.98(.10)	-9.38	<.001	.31	.38	.46
Supergame 2	-.02(.10)	-.15	.880	.81	.99	1.20
Supergame 3	-.23(.10)	-2.33	.026	.65	.80	.97
Supergame 4	-.17(.10)	-1.67	.095	.69	.85	1.03
Supergame 5	-.32(.10)	-3.17	.002	.59	.72	.88
Supergame 6	-.49(.10)	-4.73	<.001	.50	.61	.75
Supergame 7	-.16(.10)	-1.63	.104	.70	.85	1.03
Supergame 8	-.44(.10)	-4.31	<.001	.53	.64	.79
Supergame 9	-.39(.10)	-3.89	<.001	.55	.67	.82
Supergame 10	-.58(.10)	-5.58	<.001	.46	.56	.69
Game type x Time manipulation	.06(.55)	.12	.908	.36	1.07	3.11
AIC	11636.6					
Log-likelihood	-5795.3					
Number of obs.	11200					

Note. β = coefficient; *SE* = standard error of the coefficient; *CI* = confidence interval; *LL* = lower limit; *UL* = upper limit; AIC =The Akaike information criterion.

Figure 4

Cooperation Rates Across the Ten Supergames Played in the Four Conditions

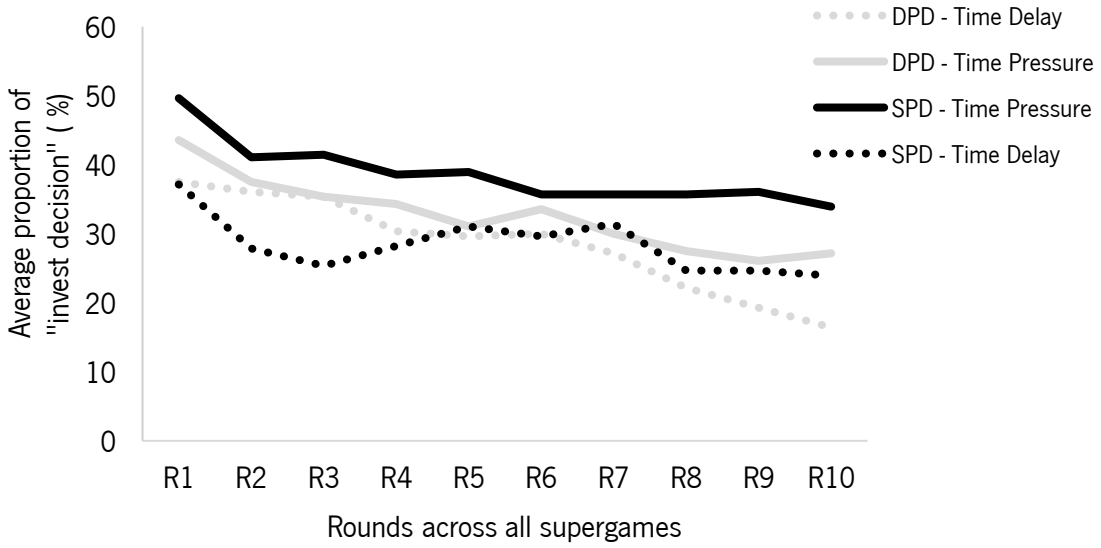


Note. *n* = 28 participants in each condition presented. A version of this figure with error bars is presented in Appendix A (Figure A.2.1).

Additionally, we apply another mixed-effect logistic regression to further explain the decreasing cooperation results across the rounds and the supergame. Specifically, we regressed each decision (1 for Investing, 0 for Not Investing) as the dependent variable on the following independent variables: supergame number, round number, and the interaction of supergame and round. The model revealed a significant effect of the round number (β = -.050, *z* =-2.90, *p* =.004, *OR* = .95, 95% CI [.92, .98]) and a significant effect of interaction between the supergame and the round (β = -.008, z = -2.78, *p* =.005, *OR* =.99, 95% CI [.99, 1.00]), such that participants learned not to cooperate over the increasing of rounds but cooperate in the beginning of each supergame (see Figure 5 for more details). However, there was not a significant difference in the supergame played (β=-.014, z = -2.78, *p* =.412, *OR*=.99, 95% CI [.95, 1.02]).

Figure 5

Mean Cooperation Rates Across the Rounds Played in all Supergames in the Four Conditions



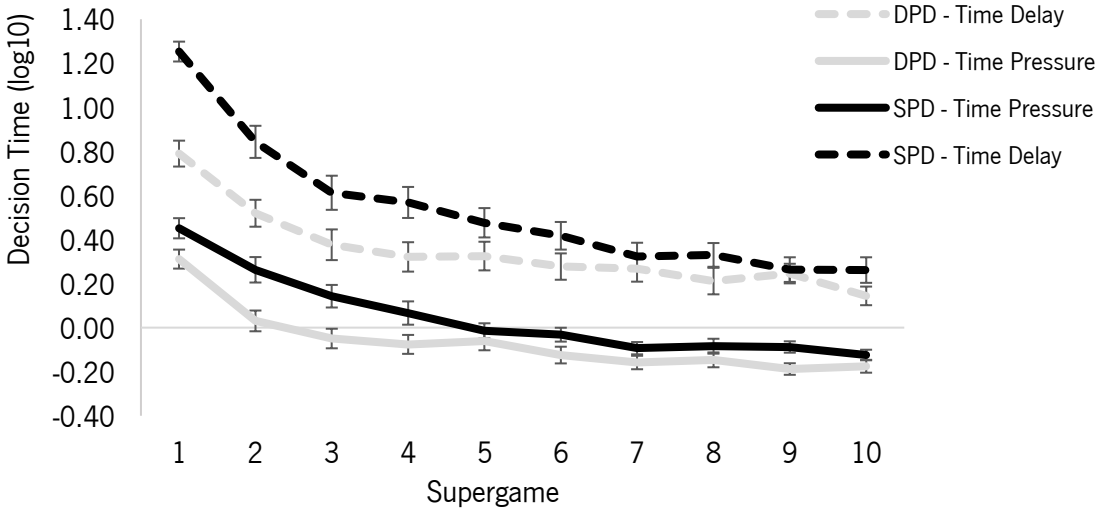
Note. n = 28 participants in each condition presented. A version of this figure with error bars is presented in Appendix A (Figure A.2.2).

2.5.4. Reaction Time Analysis

Finally, we examined the impact of the 'participants' average decision time in log 10 transformation on the different rounds played for the four conditions (Figure 6).

Figure 6

The Average Amount of Decision Time Across Conditions and Rounds Played



Note. n = 28 participants in each condition presented. Error bars represent standard errors of the mean.

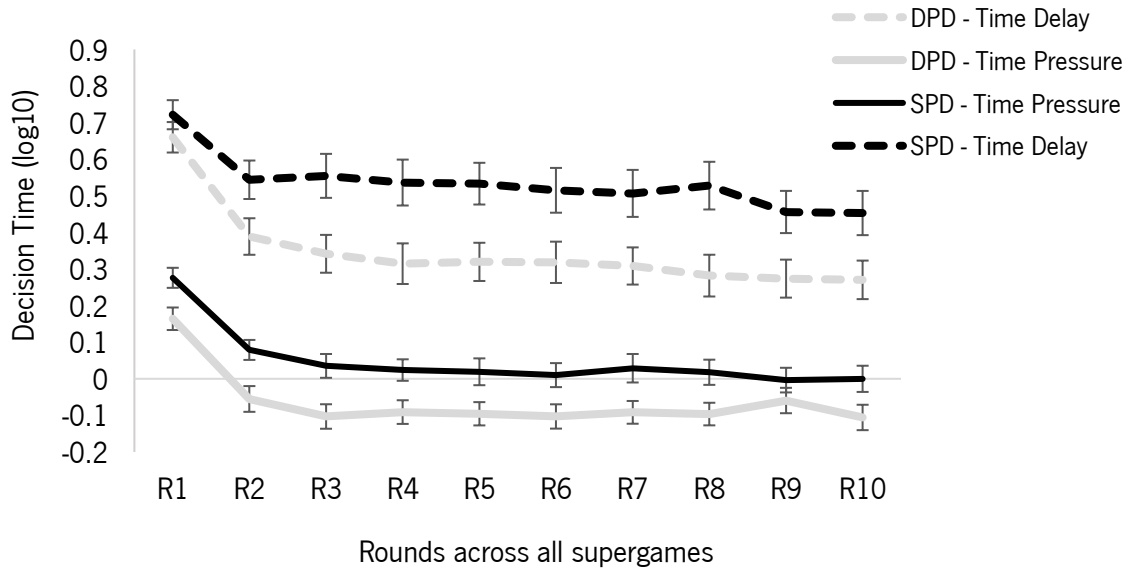
A 4 (between-subjects factor: DPD-Time Delay versus DPD- Time Pressure versus SPD- Time Delay versus SPD- Time Pressure) by 10 (within-subjects factor: supergames) by 10 (within-subjects factor: rounds) mixed design Analysis of Variance (ANOVA) was conducted on the average participants' decision time. We used this model to examine the effect of the different conditions controlling for the different individual reaction times in each round participants play.

The main effect of the type of condition was statistically significant, $F(3, 108) = 41.62$, $p < .001$, $\eta^2 = .536$; Pairwise comparisons reveal that participants under time pressure conditions in both types of games have faster reaction times compared to the time delay condition. Only the two types of games in time pressure manipulation do not differ statistically between them, $p = .064$ (M DPD = -0.06; M SPD =0.05). Participants in the SPD-Time delay condition reveal slower reaction times ($M = 0.53$), followed by participants on the DPD-Time delay condition ($M = 0.35$, see Figure 6).

The main effect of the supergame was significant, $F(9,972) = 180.327$, $p < .001$, $\eta^2 = .625$, meaning that as the experiment progressed, the reaction time decreased, and also the main effect of the rounds, $F(9,972) = 98.419$, $p < .001$, $\eta^2 = .477$, revealing that as the rounds augment, the reaction time diminishes. The interaction between these two repeated measure variables was also significant, $F(81,8748) = 2.972$, $p < .001$, $\eta^2 = .027$. With the increase of the game time (supergame x round), participants' reaction time diminishes (see Figure 7). Likewise, the two-way interactions between supergame and condition, $F(27,972) = 6.280$, $p < .001$, $\eta^2 = .149$, and round and condition, $F(27,972) = 2.414$, $p < .001$, $\eta^2 = .063$, were also statistically significant. Besides the interaction effect between the supergame, the round, and the condition was not significant, $F(243,8748) = 1.116$, $p = .106$, $\eta^2 = .030$.

Figure 7

The Average Amount of Decision Time Across the Rounds Played in All Supergames



Note. n = 28 participants in each condition presented. Error bars represent standard errors of the mean.

In order to explore whether there were any differences across the four conditions regarding individual variables, we conducted an ANOVA. Results reveal that there were no differences across the four conditions regarding the individual risk-taking propensity (p = .145), personality factors (BFI_extraversion p = .358; BFI_agreeableness p = .452; BFI_conscientiousness p = .727; BFI_neuroticism p=.138; BFI_openess p =.321), empathy (TP. p = .520; PE. p = .504; DP. p = .117; F p = .388), positive and negative affect (Pos. affect p= .306; Neg. Affect p =.468; End_Pos. Affect p = .538; End_Neg. Affect *p=.340*). Additionally, the Kruskal-Wallis test was applied to analyze whether there were any differences across the four conditions regarding the sociodemographic variables and the questions regarding the game-related questionnaire. Results reveal that there were no differences across the sociodemographic variables (Age p= .340; Gender p= .936; SES p =.610) and game-related questionnaire (Cooperate p =.713; Proximity p= .162, Pleasant p = .473; Difficulty experienced p =.097).

2.6. Discussion

The main goal of this study was to analyze the simultaneous impact of time pressure and uncertainty on cooperation in a prisoner's dilemma game under uncertainty. We observed participants' decisions in repeated interactions for ten rounds, then another ten rounds played against another randomly chosen partner, and so on, for ten sets of rounds (the supergames). Participants were informed of these aspects but not of the total number of supergames they were expected to play. In a repeated PD

game, we manipulated cognitive processes using time pressure manipulation methods on their decision. Under a time pressure condition, participants are asked to decide as quickly as possible (< 10 s). In a time delay condition, participants were asked to consider their decision carefully. Finally, environmental uncertainty was manipulated by having PD games with defined versus probabilistic outcomes. Studying how participants behave in these contexts explains the factors that determine cooperative behavior (Dal Bó & Fréchette, 2018).

Consistent with our first hypothesis and findings from other studies (Fehr & Fischbacher, 2004; Gong et al., 2009; Jordan et al., 2013), the data revealed a learning process as participants played the game repeatedly. Results showed that as the number of rounds and supergames increased, individuals learned not to cooperate with others. Even though several studies in the field of prisoner's dilemma have been conducted over the years, research in the area still tries to understand whether people learn to cooperate or defect in the game (Dal Bó & Fréchette, 2018; Embrey et al., 2018). Different studies in the literature have given contradictory results on the evolution of play with experience (Embrey et al., 2018). A recent study tried to understand cooperative behavior and its evolution with experience, and the results revealed that the characteristics and length of the supergame have considerably impacted initial cooperation (Embrey et al., 2018). For example, as the supergame length increases, the initial cooperation increase because the worth of playing conditional cooperative strategies increases (Embrey et al., 2018). Interestingly, our data show that cooperation rates increase at the beginning of each new supergame (a new interaction) but slightly less at each further interaction.

Regarding the effect of intuition on cooperation, results are consistent with previous studies (Nishi et al., 2016) and predictions of the Social Heuristic Hypothesis (Rand, 2016). Likewise, the results of applying the logistic regression model to the first fifty rounds are consistent with the second hypothesis, revealing that individuals tend to rely on a more intuitive decision-making process to cooperate. In addition, these results were confirmed in previous findings, where individuals appear to be more inclined to cooperate with others under time pressure than under time delay (Rand, 2016). However, these findings conflict with previous studies that found that deliberation plays an essential role in cooperation (Goeschl & Lohse, 2018).

The second and third logistic regression models did not reveal an effect of time pressure manipulation on cooperation. This result is consistent with our third hypothesis that intuition would not affect participants' decisions as the game progressed. Furthermore, based on the SHH predictions, intuition was expected not to affect games where it could be payoff-maximizing to cooperate (e.g., games in which reciprocity was possible; Capraro, 2019; Evans & Rand, 2019; Rand, 2016). However, other

studies exploring the effects of intuition on cooperation did not find an effect of time pressure manipulation on cooperation, even in one-shot games (Alós-Ferrer & Garagnani, 2020; Capraro & Cococcioni, 2016; Verkoeijen & Bouwmeester, 2014).

Our data appears to support the idea that the cooperative default response varies with the absolute level of cooperation a person faces in the game (Nishi et al., 2016). We found that participants learn not to cooperate with others as the game progresses. As predicted by the SHH in a repeated game, intuition does not affect cooperation. On the contrary, we found that time pressure manipulation favors cooperation in the first five supergames. Our data shows that cooperation rates are higher in participants' first decisions than cooperation rates for the last decisions. Similar to previous research, our results also demonstrate the importance of considering the social environment when examining decision time (Nishi et al., 2016). This explanation of the effect of the social environment on decision time can explain why there are mixed results in the literature and why results vary with the social environment within repeated game studies (Nishi et al., 2016; Nishi et al., 2017). Capraro and Cococcioni (2015) also concluded that cooperation is a learning process in their study, where they compared experienced participants in playing social dilemma games versus inexperienced participants. The study revealed that experienced participants playing a social dilemma game under time pressure manipulation were significantly more cooperative than naive participants. It is important to notice that other experiment report that experience negatively affects cooperation (Capraro & Cococcioni, 2015; Rand & Kraft-Todd, 2014). According to Capraro and Cococcioni (2015), both results are consistent with the SHH, suggesting that experience runs mainly through intuition (Capraro & Cococcioni, 2015). Furthermore, the SHH assumes that individuals who frequently experience cooperation tend to lean towards cooperation as the intuitive response, but not those who live in a non-cooperative context (Capraro & Cococcioni, 2015; Nishi et al., 2016; Rand & Kraft-Todd, 2014).

It is worth noting that four participants are in the room playing the game, and participants play simultaneously one supergame with one partner and then switch to another. Although it is random whom they play along in the supergame, it appears that when they repeat the previous interaction (or they start believing they are repeating previous interaction, from supergame four till the end of the game), time pressure manipulation does not have an effect, and non-cooperative behavior is augmented. Cooperation was higher than in the other rounds at the beginning of each new supergame (new interaction). This finding is consistent with the idea that daily experiences with norms and institutions initially led participants to expect others to cooperate and be inclined towards cooperation themselves (Rand et al., 2014). However, once participants start the game and learn about the other player's actions, they begin

to follow signs from the social environment in which they are inserted (Nishi et al., 2016). Previous SHH findings also emphasize that experiences from outside the lab influence participants' decisions (Rand et al., 2014), which might have influenced the initial decision of the participants, and they learn as the game progress. A recent study using a different statistical model – the Drift Diffusion Model- also found that people's initial intuitive decision is to cooperate (Gallotti & Grujić, 2019). However, deliberation becomes dominant to the detriment of an initial intuitive bias towards cooperation if the game is repeated. Gallotti and Grujić (2019) stated that in a game, when there is more defection from the other players, the intuitive decision gradually becomes to defect. In contrast, when other individuals tend to cooperate, the bias is to also cooperate. Similar to our findings, the authors found that the predisposition to cooperate is robust, such that after a pause, individuals start to cooperate as in the beginning (Gallotti & Grujić, 2019).

Another possible explanation for the positive result between time pressure manipulation and cooperation in the first 50 decisions made but not in the total decisions is that extreme time pressure decreases cooperative behavior (Capraro & Cococcioni, 2016; Evans et al., 2015). Analyzing the reaction time, we can see that participants in the analysis of the 100 decisions were quicker than in the beginning fifty decisions. As long as the game progressed, participants made their decisions quickly. Our results appear to support the idea of an inverted-U relationship between reaction time and cooperation found in the literature, where extreme time pressure manipulation declines cooperation rates (Capraro & Cococcioni, 2016). In contrast, light time pressure increases cooperation (Capraro & Cococcioni, 2016). In our results, the effect of time pressure manipulation is only significant on the first fifty decisions, where reaction times were higher than in the analysis of all decisions.

2.6.1. Effects of Uncertainty on Cooperation

Our data did not confirm our fourth hypothesis regarding the game's primary effect of uncertainty on cooperation. More specifically, we did not find an effect of the type of game (when uncertainty is present or not) on cooperation. These results are inconsistent with previous studies (Gong et al., 2009; van Dijk et al., 2004; van Lange et al., 2013). The average cooperative response across conditions suggests that participants under environmental uncertainty were more cooperative than participants who played the deterministic form of the game. Previous research found that social uncertainty undermines cooperation when people believe their choice is critical (significantly impacting the outcome; Chen et al., 1996). When criticality is low, there is a slight enhancement in cooperation rates with uncertainty (Chen et al., 1996). Based on this study, we can also suppose that participants do not perceive their choice as critical, particularly in a stochastic game version where the results are based on probabilistic outcomes.

Recent debates stated that uncertainty does not affect uniformly social interactions (Kappes et al., 2019; FeldmanHall & Shenhav, 2019). Recently, a study revealed that uncertainty does not always promote selfish behaviors (Kappes et al., 2018). Instead, they found that an individual's prosocial behavior was increased under impact uncertainty (i.e., uncertainty about how the negative outcome will affect others; Kappes et al., 2018). The authors claim that individuals are more selfish when they are uncertain about what outcomes their decisions will produce but less selfish when they are uncertain about the influence of those outcomes on others' welfare (Kappes et al., 2018).

Some studies have been interested in analyzing whether and when participants play cooperatively and the strategies used in a repeated prisoner's dilemma with uncertainty (Fudenberg et al., 2012). The study revealed that individuals tend to cooperate in repeated games with uncertainty when there is a cooperative equilibrium (i.e., both start by cooperating and remain until the first player choose to defect). The authors report that strategies, such as Tit for two Tats (TF2T, i.e., individual cooperates except if the other player chooses to defect in both of the last two rounds) that involve forgiveness are often used and can effectively obtain high outcomes; however, it is not an equilibrium for all individuals to play TF2T (Fudenberg et al., 2012). The authors concluded that forgiving others and choosing to cooperate in an uncertain world could be more payoff-maximizing than quickly reciprocating and defecting (Fudenberg et al., 2012). Therefore, it would be necessary also to analyze the strategies used in the two games we present and understand which game strategy is a good predictor of cooperation, even in a prisoner's dilemma game with probabilistic outcomes. It is also important to note that it appears that participants, as the number of rounds, increased tens to reach for the Subgame Perfect Nash Equilibrium for iterated prisoner's dilemma that is non-cooperation (*P, P*).

Furthermore, we did not find any interaction between the type of game and time pressure manipulation. Earlier, we hypothesized that time pressure manipulation augmented cooperative behavior under conditions of uncertainty, and on the contrary, we expected that cooperative behavior would decrease in uncertain conditions under time delay. This study is one of the first to analyze environmental uncertainty and time pressure manipulation to the best of our knowledge. Analyzing mean data, participants in SPD conditions under time pressure have a higher average cooperate rate. Furthermore, the effect in the stochastic game augments with time pressure manipulation. However, the average cooperation rate is similar under time delay in both types of games.

2.6.2. Limitations and Further Research

One crucial methodological option we should consider is that the game is in a loss frame. Therefore, we should consider the possibility that individual risk-seeking behavior in the loss frame might change when the game is played in the gain frame. For example, the current study uses a prisoner's dilemma game with negative outcomes to mimic a real-world scenario where players invest in reducing the risks of suffering a loss (Gong et al., 2009). Previously researchers have observed that individuals react differently to losses and gains and usually are more sensible to losses than gains (Gong et al., 2009; Everett et al., 2017; Kahneman & Tversky, 1979; Stagnaro et al., 2017). Thus, individuals will make riskier choices to avoid losses than they will to produce gains. A critical limitation of this study is that we did not assess participants' comprehension regarding the game structure. Thus, understanding the game remains a potentially problematic aspect of the dominant methodological design in this area (Capraro, 2019; Everett et al., 2017). Additionally, participants were instructed to think carefully in the time delay condition and not decide for at least 10 seconds. However, they can respond at any second. Therefore, it is essential that future research force participants' responses after a specific time.

Finally, another question concerns the payments for attending the experiment. In the present study, the reward is not directly correlated with the participant's decisions (i.e., paying a participation fee) or because a payment based on repeated trials decreases the effects (Mantilla, 2018). In our study, we attributed a monetary prize to two randomly chosen participants from all participants who completed the task. Since participants did not know the total of participants who completed the experiment, they only saw the number of participants present in their group. In this case, there is uncertainty regarding the group size of receiving the final prize. Research in group size uncertainty revealed that there is not always a negative effect on cooperation, and some studies report that uncertainty regarding the number of players has a positive effect on cooperation (Au & Ngai, 2003; Boosey et al., 2017; De Kwaadsteniet et al., 2008; Hillenbrand & Winter, 2018; Kim, 2018; Mill & Theelen, 2019).

2.6.3. Conclusions

To summarize, our study helps to clarify the mixed-effects found in the literature regarding the effectiveness of cognitive processing manipulation on cooperation (Capraro, 2019). Overall, our analysis suggests that, compared to time delay, time pressure leads to greater cooperation in the first rounds of interaction. Our data support the idea that the intuitive cooperative default response varies with the absolute level of cooperation an individual faces in the game. The results point to a direction in which participants cooperate less with their counterparts as the number of rounds increases. In addition, it

would be helpful to try to understand better how participants learn. The intuition effect found does not appear to be maintained throughout the experiment's entire duration, and neither can we rule out the effect of learning. Although our study does not find significant developments regarding the interaction effect of intuition and uncertainty under a repeated game, the generality of the findings in this area remains to be explored. Research regarding dual-process manipulation in the last eight years has led to a better understanding of the personal and environmental factors that shape cooperation and prosocial behavior (Capraro, 2019; Evans & Rand, 2019). Understanding when and why people cooperate in our society, replicating situations that we encounter in real life, like risk and uncertainty, is undoubtedly a fundamental topic for further research.

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CHAPTER 3

Empirical Study 2:

Uncertainty, Frames, and Time Constraints in Cooperative Decision-Making

3. Uncertainty, Frames, and Time Constraints in Cooperative Decision-Making

Reference:

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Results from this empirical work were presented in two scientific events:

Costa, D., Fernandes, N., Arantes, J., & Keating, J. (2022, February 3-4). *Uncertainty, frames, and time constraints in cooperative decision-making* [Conference presentation]. 1ª Convenção Psicologia U.Norte e 1º Simpósio Doutoral Psicologia U.Norte - SimPsi U.Norte [1st Psychology Convention of North University and 1st Psychology Doctoral Symposium of North University]. Porto, Portugal

Costa, D., Fernandes, N., Arantes, J., & Keating, J. (2022, May 5-7). *Uncertainty, frames, and time constraints in cooperative decision-making.* [Conference presentation]. First Joint International APPE-SEPEX Metting. Faro, Portugal

All data, analysis code, and research materials are available at: https://osf.io/7bsau/

Additionally, supplemental materials can be found in Appendix B.

3.1. Abstract

Cooperation often decreases in situations of social and outcome uncertainty. Concurrently, the social heuristics hypothesis suggests that cooperation is a default strategy in social interaction. Our study investigates the effect of cognitive processing manipulations on cooperation in experimental games that involve uncertainty and different framing contexts. We conducted two experiments, a one-shot, and a repeated prisoner's dilemma. In each experiment, 192 participants played a 2 (type of game: stochastic vs. deterministic prisoner's dilemma) by 2 (time pressure manipulation: intuition -time pressure vs. deliberation -force time delay) by 2 (frame: loss domain vs. gain domain) between-subjects design. Results from both experiments suggested that participants were more inclined to cooperate when forced to decide quickly, even when there was an uncertain outcome and in a loss frame, supporting the social heuristic hypothesis. In the repeated version (Experiment 2), cooperation decreases as the experiment progresses, suggesting a learning process. Despite the overall negative trend, there was a seasonality effect, with cooperation being higher in the initial round of each supergame compared to subsequent rounds. This effect was even more pronounced under time pressure. There was also a slower decay rate of cooperation in the stochastic condition compared to the deterministic condition, suggesting a slower learning process. Specifically, our data suggest that participants relied more on their past decisions when they had more time to reason. Enhancing our comprehension of these effects has the potential to promote new approaches to address cooperation challenges under uncertainty and time constraints.

Keywords: cooperation; learning; prisoner's dilemma; risk; time pressure; uncertainty

3.2. Introduction

One of the most common challenges we face daily is deciding whether to cooperate with others or not. For example, in our workplace, we often have to decide whether to cooperate with others to develop a joint research project (Jarke-Neuert & Lohse, 2022). This decision is even more demanding since we are often uncertain about the decision of others and the outcome of such interactions. Cooperative behaviors are essential to the development of human societies, playing an important part in addressing problems involving risk and uncertainty, such as the overexploitation of resources and epidemic outbreaks (Guo et al., 2020; van Lange et al., 2014). However, cooperation can be unfavorable since it requires individuals to pay a cost to give a benefit to another individual or group of individuals (van Lange et al., 2014; van Lange et al., 2013; Peysakhovich et al., 2014). Therefore, researchers have been interested in investigating mechanisms to sustain and promote cooperation in theoretical and empirical studies (Nowak, 2006; Rand & Nowak, 2013).

Empirical studies have been using social dilemmas to investigate cooperative behaviors because it best captures the problem of cooperation (van Lange et al., 2014). Specifically, a social dilemma is often described as a situation where an individual's self-interest (often short-term) conflicts with the collective interest (often longer-term; van Lange et al., 2014; van Lange et al., 2013). One of the most common social dilemmas used to investigate cooperative behavior is the Prisoner's Dilemma (PD) game (Dal Bó & Fréchette, 2018; Raub et al., 2015; van Dijk et al., 2004). In the standard PD, two players simultaneously decide to either cooperate or defect (Dal Bó & Fréchette, 2018). When both players cooperate, both are *rewarded* (*R*), while if both defect, both receive a *punishment* (*P*). However, when a defector meets a cooperator, the defector receives the most significant payoff, called the *temptation* (*T*), while the cooperator receives the lowest outcome possible, the *sucker's payoff* (*S*). Importantly, for the payoffs to define a PD, it must be that T > R > P > S; besides, it is often needed that 2R > S + T; as a result, switching between cooperative and defective choices cannot be considered better than mutual cooperation (Axelrod & Hamilton, 1981; Dal Bó & Fréchette, 2018).

3.2.1. The Effects of Uncertainty on Cooperation

Most studies investigating cooperative behaviors using social dilemmas have assumed that participants have complete knowledge of the dilemma's characteristics and the effects of all players' choices (van Dijk et al., 2004). However, most of our daily decisions are frequently made with incomplete information and conflicting outcomes, so uncertainty is typically present in many social dilemmas (Bendor, 1993; Boone & Macy, 2004). Researchers have distinguished between decisions made under

risk (i.e., with known probabilities) and decisions under ambiguity (i.e., with unknown probabilities; Ellsberg, 1961; Knight, 1921; Vives & FeldmanHall, 2018). For example, in social dilemmas, there is often uncertainty about what the other player will decide, and some researchers have referred to this type of uncertainty as "social uncertainty" (Biel & Gärling, 1995; van Dijk et al., 2004). In most cases, manipulations that reduce social uncertainty tend to increase cooperation in social dilemmas (FeldmanHall & Shenhav, 2019; Jorgenson & Papciak, 1981; Sniezek et al., 1990; van Dijk et al., 2004). In addition, research suggests that individuals resolve social uncertainty by anchoring decisions on norms of fairness (van Dijk et al., 2004) or by using past knowledge and contextual cues (FeldmanHall & Shenhav, 2019). In this case, individuals must depend on information about the characteristics and parameters of the dilemma (van Dijk et al., 2004). Researchers have used the term "environmental uncertainty" to refer to a situation where group members may be uncertain about the characteristics and outcomes of the dilemma (Messick et al., 1988). Additionally, findings from previous studies have suggested that environmental uncertainty diminishes cooperation (e.g., Budescu et al., 1990; Gangadharan & Nemes, 2009; Gustafsson et al., 1999; van Dijk et al., 2004; van Lange et al., 2013).

To explore the learning effects of environmental uncertainty on cooperation, Bereby-Meyer and Roth (2006) conducted a study using two PD types: a Stochastic Prisoner's Dilemma (SPD) and a Deterministic Prisoner's Dilemma (DPD). Stochastic games have outcome uncertainties in the form of binary lotteries in all strategic payoffs (i.e., risk decisions). However, in deterministic games, all strategic payoffs are known. The findings from the repeated game showed that in the DPD, participants learned to start more cooperative in the first rounds and make fewer cooperative behaviors in the final rounds, and this pattern becomes even more explicit with experience (Bereby-Meyer & Roth, 2006). On the contrary, in SPD, participants learn to cooperate more slowly due to the probabilistic payoffs, supporting the partial reinforcement learning hypothesis (Bereby-Meyer & Roth, 2006). Furthermore, the results from the non-repeated game (played 200 one-shot games) revealed that participants in the DPD learned faster to defect over time (Bereby-Meyer & Roth, 2006). However, in the SPD, participants learn more slowly to decrease cooperation, implying more cooperation in the stochastic game than in the deterministic (Bereby-Meyer & Roth, 2006).

Regarding the study of stochastic games, another line of research has attempted to understand how groups and individuals cooperate (Atanasov & Kunreuther, 2016; Gong et al., 2009, 2013; Kunreuther et al., 2009). The design adopted in these studies follows the Interdependent Security (IDS) model (Kunreuther & Heal, 2003). In IDS games, players choose if they want to invest or not, in this game, individuals suffer an investment cost to decrease the risk of having a more significant loss (Gong

et al., 2009; Kunreuther et al., 2009). In the SPD, the strategy payoffs have known probabilistic outcomes (i.e., risk). In this game, cooperation without the other player's cooperation (i.e., mutual cooperation) exposes participants to losses with known probabilities. Research has reported that individuals are more likely to be cooperative when payoffs are deterministic than in stochastic games (Gong et al., 2009; Kunreuther et al., 2009). In the study of Gong et al. (2009) and consistent with previous studies (Bereby-Meyer & Roth, 2006), the authors also reveal a learning process when participants play the game continuously, such that cooperation decreases as the rounds increase. Nevertheless, previous studies have suggested that the effects of uncertainty on cooperation may depend, among other factors, on the type of social dilemma, the type of uncertainty, and the level of risk (Boone & Macy, 2004; van Dijk et al., 2004).

3.2.2. The Effects of Intuition on Cooperation

Recent studies have focused on understanding the mechanism that makes individuals more willing to pay costs for the common good (Capraro, 2023; Rand et al., 2012). Typically, these studies use a dual-process perspective that characterizes human thinking as the interaction between two cognitive systems (Capraro, 2023; Evans & Rand, 2019). One system is fast and intuitive, while the other is slow and deliberative (Evans & Rand, 2019; Evans & Stanovich, 2013; Kahneman, 2011). Therefore, research has examined the relationship between cognitive processes and cooperation (Capraro, 2023; Isler & Yilmaz, 2019). In order to investigate the cognitive processes, researchers have used several manipulation methods such as time constraints, cognitive load, and conceptual primes (Capraro, 2023; Kvarven et al., 2020; Rand, 2016).

The primary study in the field revealed that using time pressure manipulation and conceptual priming of intuition increases cooperative behavior (Rand et al., 2012). Further research has replicated these results and revealed that the positive effect found is stronger with naive and trusting participants (Rand et al., 2014; Rand & Kraft-Todd, 2014). These findings contribute to the development of the Social Heuristics Hypothesis (SHH). Following the SHH, behaviors that are beneficial in daily life interactions (i.e., those that maximize payoffs in the long run) are internalized and retained as social heuristics or as intuitive default responses (Capraro, 2023; Rand, 2016; Rand et al., 2012; Rand et al., 2014). The internalization of these behaviors may explain why participants tend to cooperate more under intuition in one-shot games (i.e., games only played once) where cooperation is not maximizing individuals' payoff (Capraro, 2023; Rand et al., 2014). However, through a more deliberative process, individuals can override this default behavior and adopt the optimum behavior for a given situation (Capraro, 2023; Rand,

2016; Rand et al., 2012; Rand et al., 2014). Rand (2016) conducted a meta-analysis to better understand this effect, and the results support the SHH's prediction that intuition promotes cooperation in one-shot games but not in repeated games where cooperation can maximize payoff.

However, other researchers have found it challenging to provide evidence for the SHH hypothesis (Isler & Yilmaz, 2019), with several recent studies failing to replicate the effect predicted by the SHH hypothesis (Camerer et al., 2018; Tinghög et al., 2013; Verkoeijen & Bouwmeester, 2014). In a large-scale multi-lab replication of Rand et al.'s (2012) Study 7, Bouwmeester et al. (2017) also failed to find a strong effect. As in Tinghög and colleagues' (2013) study, they found that time pressure increases cooperation but only when participants who failed to comply with the time constraint were excluded from the analysis. Recent meta-analyses also suggest weak effects of time pressure on cooperation (Kvarven et al., 2020). On the other hand, studies (Capraro & Cococcioni, 2016; Goeschl & Lohse, 2018) have found the opposite effect from Rand and collaborators (2012). For instance, in Capraro and Coccocionni's (2016) study, the authors found that under extreme time pressure, there were fewer rates of cooperation in one-shot PD games.

Nevertheless, research using improved methods and addressing previous questions regarding participants' exclusions, selection bias, and comprehension checks have found support for the SHH (Everett et al., 2017; Isler et al., 2018). Furthermore, other studies found that time pressure promotes cooperation even in contexts where cooperation tends to diminish, such as with outgroup members (Rand et al., 2015), asymmetric games (Lotz, 2015), and using a competitive frame (Cone & Rand, 2014). For example, Everett et al. (2017) revealed that time pressure promotes cooperative behaviors despite being in the context of losses and concerning outgroup members. Moreover, the data showed that cooperation rates were higher in the context of gains than losses (Everett et al., 2017). According to prospect theory, people discriminate between outcomes described in terms of gains versus losses (Kahneman & Tversky, 1979). Specifically, individuals are more sensitive to losses than gains (Evans & van Beest, 2017; Novemsky & Kahneman, 2005).

One way to explain the different results found in the literature regarding the relationship between cooperation and intuition is through recent studies that suggest intuition favors self-regard, while cooperation requires reflection, supporting the Self-Control Account (Hofmann et al., 2009; Isler et al., 2021; Isler & Yilmaz, 2019; Kocher et al., 2017). To reconcile the mixed evidence found in the literature, Isler and colleagues (2021) proposed a new framework, the Contextualized Strong Reciprocity account, which argues that contextual features determine intuitive responses that, in turn, influence game understanding, beliefs, and norm perceptions, and even preferences, to shape cooperation behavior (Isler

et al., 2021). According to this framework, specific contexts, such as Maintenance dilemmas (similar to a loss frame) where participants can withdraw from the public good, are more likely to provide a stronger intuitive selfishness reaction than other contexts, such as Provision dilemmas where participants can contribute to the public good. However, regardless of this context effect, the authors demonstrated that a combination of preferences and beliefs accurately predicts a significant amount of cooperation in both maintenance and provision dilemmas.

When analyzing repeated interactions, several studies have found that individuals are influenced by the past behavior of their interaction partners (Fudenberg et al., 2012; Nishi et al., 2016; Santa et al., 2018). Additionally, research has shown that reciprocal decisions are made more quickly, suggesting that the social environment influences the speed of cooperative decisions (Nishi et al., 2016). Later, Gallotti and Grujić (2019) replicated this effect using a drift-diffusion model and found that, in a non-cooperative environment, cooperative decisions are faster only in the first round. The authors also discovered that the predisposition towards cooperation returns to the same value as in the first round after a pause (Gallotti & Grujić, 2019). Additionally, previous studies have reported a decline in cooperation in finitely repeated PGG, with cooperation resuming after a restart (Andreoni, 1988; Fischbacher & Gächter, 2010). However, these studies do not address time pressure effects when the interaction restarts, unlike Gallotti and Grujić's (2019).

In a previous study, we investigated the effect of time pressure manipulation on a repeated PD game, both with and without stochastic payoffs (Costa et al., 2022). Our findings indicated that time pressure increased cooperation during the first 50 rounds of the game. Nevertheless, the results revealed a learning process, with participants learning to defect over time. Furthermore, the positive effect of intuition on cooperation was not maintained throughout the experiment's total duration, as participants experienced a more non-cooperative environment (Costa et al., 2022). In addition, we observed an initially intuitive tendency to cooperate, which reset to higher levels at the beginning of every new interaction (Costa et al., 2022). Several studies have demonstrated that cooperation tends to decrease across repeated rounds (Andreoni & Miller, 1993; Bereby-Meyer & Roth, 2006; Gong et al., 2009). This effect can be initiated by the so-called 'conditional cooperators', who cooperate until they learn that their interaction partners are not cooperating (Fischbacher et al., 2001; McAuliffe et al., 2018) or since the repeated game have a known end, participants converge to the Subgame Perfect Nash Equilibrium (Duffy & Smith, 2014).

3.2.3. Potential Moderator's Effects on Cooperation

Recently, several studies have explored potential moderators of cooperation and found support for the SHH predictions (Capraro, 2023). In a study by Lu and colleagues (2018), the authors found that individuals with a proself orientation generally requested less money under deliberation. In contrast, prosocial individuals made similar requests in both conditions, implying a tendency to follow the equality rule intuitively (Lu et al., 2018). Later, Alós-Ferrer and Garagnani (2020) found no general effect of time pressure on cooperation. However, they found that time pressure interacted with Social Value Orientation (SVO), making prosocial individuals even more prosocial, leaving individualists unaffected, and making competitors more competitive. The authors concluded that intuition promotes default behavior in the context of social cooperation but that this behavior depends on individual differences (Alós-Ferrer & Garagnani, 2020). This conclusion was also found in an earlier study by Mischkowski and Glöckner (2016), which suggested that prosocial individuals reduce cooperative behavior with increasing decision time (Mischkowski & Glöckner, 2016).

Previous studies have also aimed to explain the diversity of behavior in cooperation through the impact of personal characteristics (Dal Bó & Fréchette, 2018; Dreber et al., 2014; Proto et al., 2019), such as risk attitudes, gender, and personality measures, and economic training (Dal Bó & Fréchette, 2018). Research has indicated that time pressure can increase cooperation in men with a low risk-taking propensity, but it can decrease cooperation in men with a high risk-taking propensity (Bird et al., 2019). However, the association between risk preferences and cooperation in the PD game is still unclear, and the findings from various studies are divergent (Dal Bó & Fréchette, 2018; Parks, 2004; van Assen & Snijders, 2004). A one-shot PD study suggested that there was no significant effect between risk orientation and cooperative behavior (De Heus et al., 2010). Additionally, repeated PD game research did not find a strong relationship between risk attitude and cooperative behavior (Davis et al., 2016; Dreber et al., 2014; Proto et al., 2019). Glöckner and Hilbig (2012) suggested that the effect of risk preferences on cooperation differs according to the environment of the game. Specifically, risk aversion only favored cooperation in environments where cooperation is friendly. Au et al. (2012) suggested that the different results could be due to the difficulty in defining the risk of cooperation and defection in PD, so the authors designed an index of game riskiness (r) to measure the cooperation risk in a PD. In a one-shot PD game, Au et al. (2012) and Ng and Au (2016) found that risk-seeking individuals cooperate more in games where cooperation is more risky, whereas risk-aversive individuals cooperate more in games that are less risky. Numerous studies have also attempted to explore the effect of time pressure on risk decisions (Kocher et al., 2019; Ordóñez et al., 2015). Nevertheless, the effect of time pressure on risky

decisions remains unclear (Kocher et al., 2019; Olschewski & Rieskamp, 2021; Ordóñez et al., 2015). Previous studies have suggested that individuals become less risk-averse in the gain domain under time pressure (Madan et al., 2015; Nursimulu & Bossaerts, 2014; Saqib & Chan, 2015). On the other hand, research has suggested that individuals become more risk-averse under time pressure (Ben Zur & Breznitz, 1981; Gawryluk & Krawczyk, 2019) and have suggested more loss aversion (Kocher et al., 2013). However, Kirchler et al. (2017) revealed that time constraints influence individuals to take fewer risks in a gain frame and to take more risks in the loss domain. Research has highlighted the need for an improved theoretical framework to describe how time constraints affect decisions made under risk (Ordóñez et al., 2015). For example, Olschewski and Rieskamp (2021) suggested that time pressure may lead individuals to make less consistent choices when faced with risky decisions, regardless of their underlying risk preferences.

3.2.4. The Present Work

This research aims to explore the effect of cognitive processing manipulations on cooperation in a social dilemma game involving uncertainty and risk through the experimental manipulation of time pressure. It will contribute to the debate regarding the effects of intuition on cooperation (Capraro, 2023; Rand et al., 2012; Rand, 2016) and validate it in different contexts that have not been fully addressed yet (Costa et al., 2022). More specifically, we will analyze how time pressure influences cooperative decision-making across different contexts, such as stochastic vs. deterministic payoffs and gain vs. loss framing.

In this study, we also address limitations identified in a previous research by Costa et al. (2022), including the lack of a forced time delay condition that leads to quicker reaction times in the time delay condition previously presented and the non-comprehension of the game structure. Finally, we expect to make theoretical contributions regarding the consequences of framing a social dilemma in a loss versus gains context. We expected that the modifications made from the previous study would increase cooperation rates since previous research has suggested that time pressure positively affects cooperation for those who understand the game's payoff structure (Isler et al., 2018; Strømland et al., 2018). Additionally, Everett et al. (2017) revealed higher cooperation rates in the gain frame of the PD game. Furthermore, introducing a forced time delay will allow for more accurate manipulation of deliberation.

In this study, we aim to enlighten the cognitive processes that underlie cooperative decisions that involve some level of risk and uncertainty through the experimental manipulation of time pressure by conducting two experiments. In Experiment 1, participants played a one-shot game in a stochastic or a deterministic prisoner's dilemma game in either a gain or loss frame. This experiment will provide a better

test of the predictions of the SHH across different contexts. In Experiment 2, participants played a repeated game to give more strength to the effects found in the first experiment and allow for an analysis of the effects of learning. Considering recent suggestions regarding the lack of studies considering individual difference moderators of the time pressure manipulation effect on cooperation (Alós-Ferrer & Garagnani, 2020; Lu et al., 2018), our study will also investigate the potential moderator effects in both experiments of the SVO and risk-taking propensity.

3.3. Experiment 1

Experiment 1 aims to directly test the SHH hypothesis by having participants play a one-shot game. This experiment proposes to examine the impact of intuitive mental processing on cooperation through a time-pressure manipulation and to validate it in a different context involving outcome uncertainty and a loss frame. First, we hypothesized that participants under time pressure would be more inclined to cooperate, supporting the SHH (Rand et al., 2014; Rand, 2016). Specifically, we expected higher cooperation rates when participants were in a time-pressure condition compared to a forced time delay.

In addition, we aim to examine the effect of uncertainty on individual cooperation. We want to determine whether the effect of the stochastic games used in IDS games within repeated games is maintained in a one-shot game (Gong et al., 2009; Kunreuther et al., 2009). The authors found that individuals cooperate more in the deterministic version of the PD than in the stochastic version of the game in repeated games (Gong et al., 2009; Kunreuther et al., 2009). Therefore, in our second hypothesis, we expected that participants would cooperate more in the deterministic version of the PD than in the stochastic version of the game in a one-shot game. Regarding the main effect of the type of frame according to Everett et al. (2017) findings, our third hypothesis predicts that participants will cooperate more in the gain domain than in the loss domain. Furthermore, we expect that manipulating time pressure would increase cooperative behaviors even in contexts where cooperation rates are usually lower, such as in the loss frame and the SPD (Hypothesis 4).

3.3.1. Method

3.3.1.1. Participants. Our sample consisted of 192 university students (131 women, 61 men) aged between 17 and 40 years of age (M = 20.92, SD = 3.63). The majority were Portuguese (n = 176; 91,7%), and most participants (n = 70; 36.5%) reported being in the psychology course and in the first year (n = 62; 32.3%). Regarding socioeconomic status (SES), most participants reported having a medium socioeconomic status (n= 115; 59.9%) (for more details, see Appendix B -Table B.1.). The University of

Minho Ethics Committee for Research in Social and Human Sciences approved the study. Students who had previously participated in laboratory studies involving social dilemmas were not eligible to participate in this experiment. Participants were naive about the experimental procedure and received credit courses for their involvement. However, five students who did not meet the criteria to receive credit courses showed interest in participating (two were Ph.D. students, two were in the Interuniversity Master's program, and one was from the Zootechnical Engineering major). At the end of the experiment, two participants were selected (randomly) to obtain a prize; the selected participants obtained a gift card proportional to the points earned in the game task.

3.3.1.2. Materials.

3.3.1.2.1. Sociodemographic Questionnaire. This questionnaire was designed to measure the following constructs: age, gender, nationality, socioeconomic level, field of study, and the year they attended.

3.3.1.2.2. Balloon Analogue Risk Task (BART; developed from Pleskac & Wershbale, 2014). This task evaluates individual risk-taking propensity. In this task, participants saw 30 blue balloons on a computer screen. They could press the 'e' key to pump the balloon and earn points (10 points per pump) and the 'p' key to stop pumping and receive the points made until that moment. The screen displayed the total points earned in the experiment until that moment, the number of pumps given so far in that balloon trial, and the points earned so far in that balloon trial. The balloon could explode after a randomly assigned number of pumps (an average of 64 pumps), using the same methodology as Pleskac and Wershbale (2014). Participants did not know when the balloon would explode If it exploded, the participant lost all points earned in that trial. After each balloon trial, they received feedback on whether the balloon exploded and how many points they earned (or not) in that balloon. After participants received the feedback, a fixation cross appeared for 1 second before the subsequent ballon trial began. Participants completed one practice trial before starting the task to ensure they understood the instructions. When the task ended, a BART (risk-taking) score was computed by averaging the number of pumps for all unexploded balloons. A higher adjusted value (i.e., the mean number of pumps eliminating balloons that exploded) score in the BART task indicates a higher level of risk-taking (Lejuez et al., 2002; Liu et al., 2021). In Experiment 1, one participant's response to the BART task was not recorded due to a technical error. Given the suggestion of the imputation method, we calculated the mean and used this value in the data analysis (Bennett, 2001).

3.3.1.2.3. Social Value Orientation *(SVO; Murphy et al., 2011).* The SVO slider measure evaluates individuals' concern for others. In this study, we used the 15 primary and secondary items

developed from Murphy et al. (2011). In this task, participants have to select the allocation of points that determine their chosen distribution with another participant. It is presented to each participant in each of the 15 item's nine options that differ in the number of points the participant received in comparison to the other. For example, in one of the items, participants choose among one of the following allocations: "*You: 50, The other: 100; or You: 54, The other: 89; or You: 59, The other: 79; or You: 63, The other: 68; or You: 66, The other: 58; or You: 72, The other: 47; or You: 78, The other: 36; or You: 81, The other: 26; or You: 85, The other: 15".* The method to score this measure is described in detail by Murphy et al. (2011). Specifically, results are presented as a continuous ratio score demonstrating the degree to which each participant benefits himself relative to the other individual (Murphy et al., 2011). The lowest score range indicates a competitive orientation. The scores that follow indicate an individualistic orientation followed by a prosocial orientation. The maximum range represents an altruistic attitude. Competitors and individualists were classified as proselfs based on standard practices (e.g., Lu et al., 2018).

3.3.1.2.4. Interpersonal Reactivity Index *(IRI; Davis, 1983; Portuguese version adapted by Limpo et al., 2010).* This questionnaire consists of 24[4] statements about emotions, which the participant might or might not have encountered. It comprises four subscales, specifically Perspective Taking (PT), Empathic Concern (EC), Personal Discomfort (PD), and Fantasy (F), each containing six statements. Participants rate the extent to which each statement describes themselves using a 5-point Likert (0 = *''Does not describe me well''* to 4 = *''*Describes me very well*''*). One example of the Empathic Concern subscale statement is ''I frequently experience tender and concerned emotions towards those who are less privileged than me''. According to Limpo et al. (2010), the 24-item instrument reveals a good internal consistency in the measurement of empathy (PT Cronbach's α = 0.73; EC Cronbach's α = 0.76; PD Cronbach's α = 0.80; F Cronbach's α = 0.84).

3.3.1.2.5. Short-form of the Positive and Negative Affect Schedule *(PANAS – SF; Watson et al., 1988; Portuguese version adapted by Galinha et al., 2014)*. This instrument evaluates positive and negative affect and estimates the participants' emotional state. It consists of ten emotions, five of which measure positive mood states (such as *''enthusiastic''* and *''inspired''),* and the other five measure negative mood states (such as *''nervous''* and *''guilty''*). Participants used a 5-point Likert (1 = *"Very little or nothing",* to 5 = *''*Extremely*''*) to rate the degree they are experiencing the emotion presented

[4] Limpo et al.(2010) excluded one item from each subscale in the Portuguese validation based on the factorial analyses and a conceptual basis. According to the authors the 24-item model revealed a better fit for the Portuguese data (Limpo et al., 2010).

in each item at that moment. The Portuguese version indicates good internal reliability (Positive affect α = 0.86, negative affect α =0.89; Galinha et al., 2014).

3.3.1.2.6. Final questionnaire. At the end of the session, we asked participants to answer a short questionnaire (with seven questions) to ascertain their strategies and thoughts regarding the game task, similar to Costa et al. (2022). The questionnaire began with one open-ended question that asked participants to indicate the strategy used during the game task. Participants stated on a 7-point Likert scale (1 = *"Very little or nothing"* to 7 = *"Extremely"*) how close and cooperative they were in real life with the other players present in the game task. In addition, participants also responded to four questions concerning the implementation of the game task (i.e., how pleasant, how stressful, the difficulty, and the comprehension of the instructions and the task).

3.3.1.3. Procedure. The experiment was conducted in the Human Cognition laboratory at the University of Minho using E-prime 2.0 software (Psychology Software Tools, 2002; Schneider et al., 2002) and z-Tree (Fischbacher, 2007). The students came to the laboratory in groups of four participants, and each group was randomly allocated to one of the six conditions. The experiment had a between-subject design with three independent variables: Type of game (DPD vs. SPD), Time manipulation (forced time delay vs. time pressure), and Type of frame (gain vs. loss), resulting in eight groups of participants. Participants were individually assigned to a computer station, which was separated from other stations by cubicle dividers. Participants authorized and signed an informed consent form and started by responding to the sociodemographic questionnaire and the Positive and Negative Affect Schedule short form (PANAS-SF). Before beginning the experiment, they received general instructions and completed a comprehension task with a PD game similar to the one they would play later in the session, but with different outcomes. During the general instructions, participants were informed that two random participants would receive a gift card with a payment proportional to the points gained in the game task. Next, participants responded to a comprehension check to confirm that they knew the different potential payoffs of the game by indicating the separate outcomes each player could obtain based on the example payoff matrix. Once they had responded correctly, participants were introduced to the game.

At the beginning of the game task, participants read the instructions according to their condition. See instructions at the Open Science Framework (OSF; https://osf.io/7bsau/). The outcomes of strategies on the SPD were subject to probabilistic payoff (see Tables 8 and 10). In this game, participants know that cooperation (i.e., investment) without the other player's subsequent cooperation would determine the probability of losses or gains. The corresponding deterministic game was obtained by exchanging the values and probabilities within the SPD with their respective expected values (obtained by

multiplying each value by its corresponding probability; see Tables 9 and 11). The values used in the two games were similar to the study reported by Gong and collaborators (2009) and Costa et al. (2022).

Table 8

Payoff Matrix of the Stochastic Prisoner's Dilemma Game in the Loss Frame

	Player 2		
Player 1		Invest	Not Invest
	Invest	-45; -45	20% lose 145, 80% lose 45; 35% lose 100, 65% lose 0
	Not Invest	35% lose 100, 65% lose 0; 20% lose 145, 80% lose 45	55% lose 100, 45% lose 0; 55% lose 100, 45% lose 0

Table 9

Payoff Matrix of the Deterministic Prisoner's Dilemma Game in a Loss Frame

	Player 2		
Player 1		Invest	Not Invest
	Invest	-45; -45	-65; -35
	Not Invest	-35; -65	-55; -55

Table 10

Payoff Matrix of the Stochastic Prisoner's Dilemma Game in the Gain Frame

	Player 2		
Player 1		Invest	Not Invest
	Invest	55; 55	35% gain 100, 65% gain 0; 20% gain 145, 80% gain 45
	Not Invest	20% gain 145, 80% gain 45; 35% gain 100, 65% gain 0	45% gain 100, 55% gain 0; 45% gain 100, 55% gain 0

Table 11

Payoff Matrix of the Deterministic Prisoner's Dilemma Game in the Gain Frame

	Player 2		
Player 1		Invest	Not Invest
	Invest	+55; +55	+35; +65
	Not Invest	+65; +35	+45; +45

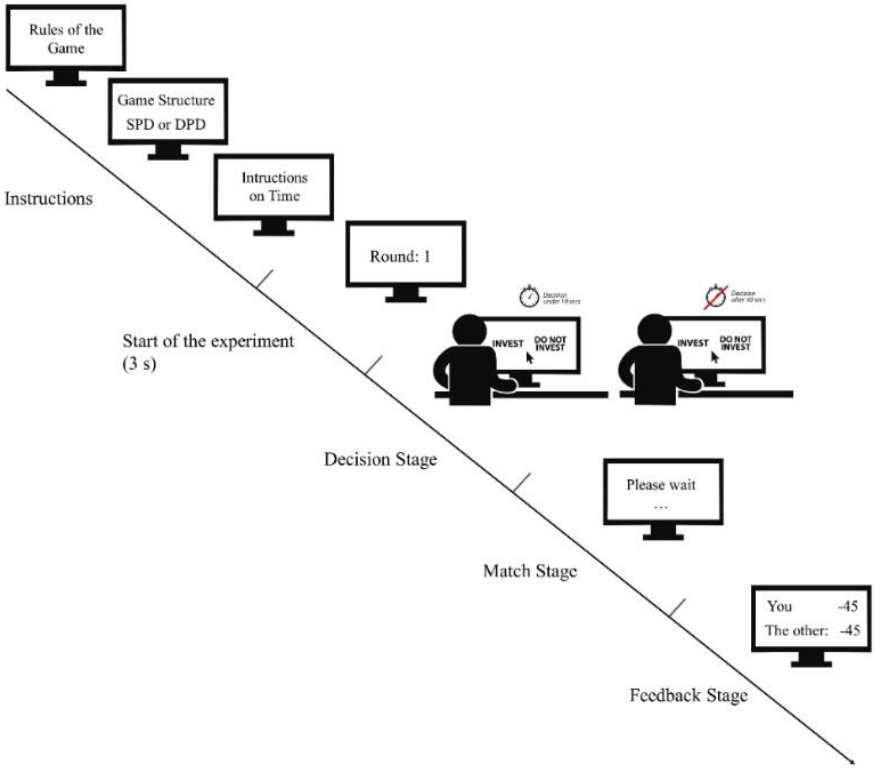
Participants played a one-shot game (one round) against one of the players also present in the experimental room. In the loss frame, each player started the game with 1500 points and faced a cost to make a decision. Therefore, each participant invested the initial 1500 points to avoid losing more points. Their goal was to avoid losing points while retaining as many as possible. On the other hand, in the gain frame context, participants did not receive any points at the beginning of the game, and their objective was to gain the highest possible points.

After the instructions concerning the rules and structure of the game, participants read the instructions about time manipulation. Under the time pressure manipulation, participants were instructed to decide as fast as they could, with a 10-second deadline. In this circumstance, a countdown appeared on the screen to indicate the remaining decision time. In the beginning, the time number was green until it reached the 6 seconds left to decide; then it turned yellow, and in the last 3 seconds, the timer number is shown in red. However, participants could still answer after the 10 seconds deadline, at which point the clock alerted them that the time had expired. In contrast, participants in the forced delay condition were instructed to think about their decision cautiously and to abstain from deciding for at least 10 seconds (in this condition, participants had unrestricted time to respond but were forced to wait for 10 seconds before any answer could be inserted). No timer appeared in this condition, but the buttons to decide whether they want to invest or not only appeared after 10 seconds.

After reading the instructions, the round number appeared for 3 seconds on the screen, indicating that the task would initiate. Upon moving to the decision screen, participants observed the game's structure and the time manipulation information (congruent with their condition). In addition, the decision screen displayed the following information "*The opponent is presently making a choice. You will not learn their decision until after you have submitted your own. Please make and submit your investment selection*", similar to previous research (Costa et al., 2022; Gong et al., 2009). This screen constituted the decision phase, where participants could choose to invest by clicking on the correspondent button. Participants were then required to wait for the other player's decision, called the match stage. Finally, after both players had decided and the match stage was over, the feedback stage appeared, where participants were presented with information regarding both options and the final payoffs. Figure 8 provides a visual illustration of the procedure.

Figure 8

Game Task Description



Then, participants completed two tasks: the SVO and the BART. Finally, they answered the PANAS-SF, the game-related questionnaire, and the IRI. The session lasted approximately 40 minutes under the time pressure condition and about 45 minutes under the time delay condition.

3.3.2. Data Analysis

We conducted a logistic regression to assess the effects of time manipulation, type of game (Stochastic vs. Deterministic), and type of frame (gain vs. losses) on participants' likelihood to cooperate in a one-shot PD using R (R Core Team, 2021), and RStudio (RStudio Team 2021; Version 1.4.1103). The logistic regression model analyzed how participants made a binary decision (1-Invest or 0-Not Invest) in a one-shot PD depending on time manipulation, the type of game, frames, and underlying interaction effects. Additionally, we addressed recent concerns regarding the interaction effect between social value orientation and time manipulation. We also introduced the interaction effect between the adjusted values of the BART task with the type of game, the type of frame, and time manipulation. Since we did not find significant effects in the covariates and the interaction effect, we conducted a second logistic regression model to present the results that model the experimental design itself.

In Appendix B.2. (Table B.2.1.), we introduced the complete model (including all predictors and their interactions). In this model, we added sociodemographic variables (such as gender and socioeconomic level), individual characteristics (such as empathy and the mood previous to the start of the task), and inherent task aspects (e.g., difficulty, pleasantness, proximity, and daily cooperation with the other players) as covariates. All data, analysis code, and instructions are available at the OSF(https://osf.io/7bsau/).

3.3.3. Results

In our first logistic regression (see Table 12), we began by fitting the manipulated variables in the game, including all predictors and their interactions. Additionally, we introduced covariates, such as SVO and its interaction effect with time manipulation, and risk-taking propensity and its interaction with the manipulated variables in the game task (Model 1 in Table 12). In the second logistic regression, we introduced the variables of the game task present in the first model and the interaction effects. Finally, we reported the results of the best-fitting model, Model 2 (the model with the lowest AIC- Akaike's Information Coefficient; Akaike, 1998). Additionally, we used a likelihood ratio test to compare the two models, and the results revealed no difference between them ($\chi2(6)= -9.04$, $p = .172$).

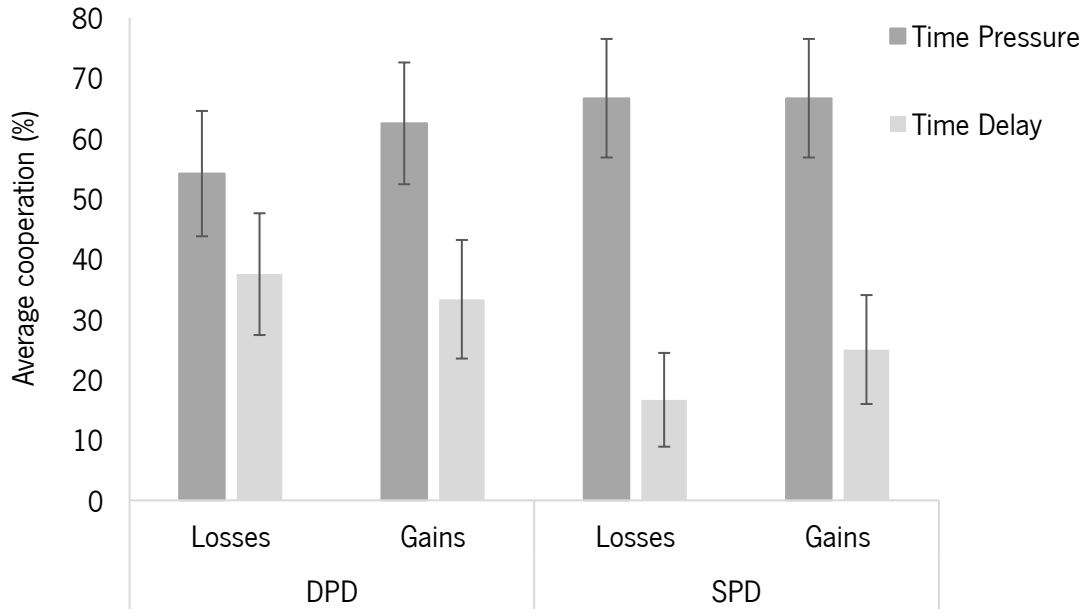
In the second model (see Figure 9 and Table 12), results revealed the main effects of time manipulation ($\beta = 2.30$, $z = 3.30$, $p = .001$, $OR = 10.00$, 95% CI [2.75, 44.21]), showing that participants cooperate more under time pressure (62.5 %) than under forced time delay (28.1%). On the other hand, results did not reveal a significant main effect of the type of game ($\beta = 1.10$, $z = 1.59$, $p = .112$, $OR = 3.00$, 95% CI [0.81, 12.85]). However, the mean data suggest that participants cooperate slightly more in the DPD (46.9%) than in the stochastic game (43.8%). Furthermore, the results did not show a significant effect on the type of frame ($\beta = 0.51$, $z = 0.71$, $p = .480$, $OR = 1.67$, 95% CI [0.41, 7.43]), although participants appear to cooperate more under a gain frame (46.9%) than in a loss frame (43.8%).

Regarding the interaction effect, we found a marginally significant effect between the time manipulation and the type of game played ($\beta = -1.62$, $z = -1.78$, $p = .075$, $OR = 0.20$, 95% CI [0.03, 1.14]). Furthermore, Posthoc test using Bonferroni correction revealed a significant effect in the SPD game, such that participants under time delay cooperate less than under time pressure ($\beta = -2.05$, $z = -4.32$, $SE = 0.47$, $p < .001$, $OR = 0.16$, 95% CI [0.07,0.37]). Nevertheless, post-hoc tests did not reveal any other significant interaction effect between time manipulation and the type of game. Since the first model revealed a significant effect between game and time, we also conducted the same post-hoc analysis on the first model, and the results revealed the same pattern as in the model reported. Finally, results did

not reveal an interaction effect between the time manipulation and the type of frame (β = -0.51, z = -0.54, p = .590, *OR* = 0.60, 95% CI [0.09, 3.81]) or a significant effect of the interaction between the type of game and the type of frame (β = -0.69, z = -0.74, p = .462, *OR* = 0.50, 95% CI [0.08, 3.13]). Results also did not reveal an interaction effect between the three variables in the game task (β = 1.04, z = 0.82, p = .414, *OR* = 2.82, 95% CI [0.24, 34.83]).

Figure 9

Average Cooperation Rates (Average Proportion of Times Participants Invested) in a One-Shot Game Across Conditions



Note. n = 24 participants in each condition presented. Error bars represent standard errors of the mean.

Table 12

Estimates of the Logistic Regression for Cooperation Probability in the One-Shot PD Game

	Model 1				**Model 2**			
		95 % CI for odds ratio				95 % CI for odds ratio		
	β (SE)	*LL*	*Odds ratio*	*UL*	*β (SE)*	*LL*	*Odds ratio*	*UL*
Intercept	-.78(.84)				-1.61(.55)**	.06	.20	.53
Game [DPD]	.65(1.00)	.27	1.92	14.35	1.10(.69)	.81	3.00	12.85
Time [Pressure]	3.17(1.03)**	3.41	23.89	196.22	2.30(.70)***	2.75	10.00	44.21
Frame [Gain]	.25(.98)	.19	1.29	9.04	0.51(.72)	.41	1.67	7.43
Game*Time	-2.13(.99)*	.02	.12	.77	-1.62(.91)	.03	.20	1.14
Game*Frame	-.83(.98)	.06	.43	2.90	-0.69(.94)	.08	.50	3.13
Time*Frame	-.78(1.01)	.06	.46	3.25	-0.51(.95)	.09	.60	3.81
Time*Frame *Game	1.47(1.34)	.32	4.33	62.77	1.04(1.27)	.24	2.82	34.83
SVO [Proself]	-.03(.54)	.33	.97	2.77				
SVO [Proself] *Time	-1.19(.73)	.07	.31	1.28				
Adj.BART	-.03(.02)	.92	.97	1.02				
Adj.BART*Time	-.01(.02)	.95	.99	1.04				
Adj.BART*Game	.02(.02)	.97	1.02	1.07				
Adj.Bart*Frame	.01(.02)	.97	1.01	1.06				
N	192				192			
AIC	255.85				252.89			
Log-likelihood	-113.94				-118.46			
R^2 Tjur	0.178				0.137			

Note. β = coefficient; *SE* = Standard Error of the coefficient; *CI* = confidence interval; *LL* = lower limit; *UL* = upper limit; Adj.= Adjusted Values; AIC =The Akaike information criterion.

* $p < .05$. ** $p < .01$.*** $p < .001$.

3.3.4. Discussion

This experiment aimed to investigate the effect of cognitive processing manipulations on individual cooperative decisions in a one-shot PD game involving uncertainty in different contexts of losses and gains. Regarding the first hypothesis, the results found in Experiment 1 revealed that time pressure manipulation favors cooperation in a one-shot game, as suggested by the SHH (Rand, 2016; Rand et al., 2012; Rand et al., 2014). Furthermore, our findings suggested that time pressure manipulation also favors cooperation, even in games involving outcome uncertainty and a loss frame, supporting previous studies that revealed that time pressure enhances cooperation in other contexts where cooperation may not be advantageous (Cone & Rand, 2014; Everett et al., 2017; Lotz, 2015; Rand et al., 2015)

Our results did not reveal a significant main effect of the type of game and, subsequently, did not offer support for our second hypothesis concerning the effect of playing a deterministic or stochastic game on cooperation. However, the mean values revealed the same tendency consistent with previous studies using a repeated game, with participants cooperating more in a DPD than in the SPD (Gong et al., 2009; Kunreuther et al., 2009). In this case, our results appear consistent with an alternative hypothesis based on the results reported in a non-repeated game of Bereby-Meyer and Roth (2006), which revealed a similar cooperation rate in the first round of the stochastic and deterministic prisoner's dilemma games.

Contrary to our third hypothesis and the study by Everett et al. (2017), we did not find a significant difference in the type of frame. Although, when analyzing mean data, participants seem to cooperate more in the gain than in the loss frame. Even so, these results appear to support De Heus et al. (2010) findings, which did not report an effect of the type of frame in a one-shot PD. The authors justify this effect by explaining that the prospect theory findings only apply to social dilemmas when it is clear the distinction between more risky and less risky decisions (De Heus et al., 2010). In the DPD we applied, and the PD reported in the study by de Heus et al. (2010), there is no risky decision because the two options (defect or cooperate) do not differ in terms of variance, and defection is the dominant strategy in these games. However, the authors found a valence effect in the Chicken Game, where there is more cooperation in the gain than in the loss domain (in this game, defection is the high-risk option, whereas cooperation is relatively low-risk) (De Heus et al., 2010).

However, within the stochastic game, deciding to cooperate could be considered a low-risk choice due to the absence of stochastic payoffs in the mutual cooperation option (Atanasov & Kunreuther, 2016). On the other hand, selecting not to invest (i.e., defect) represents the decision that could minimize losses and maximizes gains. Further research should analyze whether participants perceive cooperation in the

SPD games as a more cautious decision, as in the study by Atanasov and Kunreuther (2016). Additionally, following the calculation of the index of game riskiness (*r*) our two games are risk-neutral ($r = .5$; Au et al., 2012; Ng & Au, 2016).

We found a marginally significant effect regarding the interaction between time manipulation and the type of game. Further post-hoc tests revealed significant differences only in the SPD game, where participants in a condition to decide quickly cooperate more than in the condition where they were forced to wait. In a recent simulation model of the evolution of cooperative behavior, the authors showed that uncertainty about the outcomes of cooperating may have contributed to the evolution of social heuristics (van den Berg & Wenseleers, 2018). Results from this study imply that social heuristics could develop when uncertainty is moderate to high and are associated with greater cooperation levels than using more complex strategies that evolved when uncertainty was low (van den Berg & Wenseleers, 2018). Later, van den Berg and colleagues (2021) showed in a repeated game that participants seem to base their decision on a situation they might anticipate or that they believe is typical given the uncertainty present rather than taking into account the consequences of their behavior in all potential situations (relying on more complex strategies; van den Berg et al., 2021). These findings may help explain our results since when participants have less time to think in a time-pressure condition, they resort to the use of social heuristics. They use the typically advantageous behavior in daily life, which becomes internalized and automatically applied as an intuitive default behavior (Rand et al., 2014). Our results also seem consistent with a recent experiment where the authors found that time pressure drives information avoidance because it allows decision-makers to make fast decisions without resolving potential conflicts (Jarke-Neuert & Lohse, 2022). However, the authors also revealed that time pressure did not affect prosocial behavior when results from all players were visible (Jarke-Neuert & Lohse, 2022). Our results regarding the interaction effect involving the type of game and time manipulation revealed that time pressure in the deterministic game does not seem to have a significant effect. However, in the stochastic game, participants seem to choose the option where they do no not have to resolve potential conflicts.

Contrary to the results of Alós-Ferrer and Garagnani (2020), we did not find an effect of the interaction between social value orientation and time pressure. Their study had a within-subjects design, where participants first played a one-shot and then a repeated Public Good Game. However, we did not replicate this effect in this experiment using a one-shot deterministic and stochastic PD. This effect can be explained by the fact that we used different social dilemma paradigms, and contrary to Alós-Ferrer and Garagnani (2020), we did not gradually incentivize our participants to comply with time manipulations. Like De Heus et al. (2010) findings in a one-shot PD game and results from repeated games (Davis et

al., 2016; Dreber et al., 2014; Proto et al., 2019), we did not find a robust effect of risk-taking propensity on cooperation in a one-shot PD game. Furthermore, we did not find an interaction effect between risk-taking propensity and the three variables studied (time pressure manipulation, type of game, and the type of frame).

In this experiment, using a one-shot paradigm, results reveal a significant main effect of time pressure. Additionally, contrary to previous experiments (Alós-Ferrer & Garagnani, 2020), intuition does not seem to enhance intrinsic predispositions. Nevertheless, previous research in this area has alerted to the problem of non-compliance with the time limits and has suggested that the solution to eliminate the noncompliant participants carries problems such as selection bias (Bouwmeester et al., 2017; Everett et al., 2017; Tinghög et al., 2013). In this experiment, we report a low noncompliance rate with time pressure manipulation since only four participants failed to respect the time pressure and respond after the 10 seconds limit. Additionally, we conducted a sensitivity analysis, excluding the noncompliance participants, and the results were similar to the analysis reported with all participants. In sum, the results found in the one-shot game support the SHH and its application in a different context. However, studying only one-shot games does not inform us how participants learn across time and in different games. Systematically studying the behavior of participants in repeated games allows us to gain a deeper understanding of the determinants of cooperation (Dal Bó & Fréchette, 2018). Additionally, analyzing a repeated game experiment (within-subjects design) will allow for more powerful tests of the interaction effects.

3.4. Experiment 2

In experiment 2, we analyzed a repeated version of a stochastic and deterministic prisoner's dilemma game to clarify the relationship between time manipulation and cooperation under outcome uncertainty. This experiment will also help advance the understanding of the effects of learning during the game (Bereby-Meyer & Roth, 2006). Taking into account the modifications from the previous study (Costa et al., 2022), namely the introduction of a comprehension task and a gain frame, we considered it would produce more cooperation rates. As well as, forcing participants to wait will provide a better measure of manipulating deliberation because we would not have the effects of extremely quick responses at the end of the game in the time delay condition (Costa et al., 2022).

Therefore, we hypothesized that cooperation rates would be higher in the time pressure condition compared to a forced time delay (Hypothesis 1). Based on previous research on the effect of decision time on cooperation in a repeated game (Costa et al., 2022; Gallotti & Grujić, 2019), we expected

cooperation rates to be higher in the first round of each supergame, especially in the time pressure condition, suggesting an initial intuitive bias toward cooperation (Hypothesis 2). Our third hypothesis was that cooperation rates would be higher in the deterministic than in the stochastic version of the game, following previous findings regarding the effect of outcome uncertainty on cooperation in repeated PD games (Gong et al., 2009; Kunreuther et al., 2009). Similar to the hypothesis from the first experiment regarding the type of frame and according to previous research (Everett et al., 2017; Kahneman & Tversky, 1979), we expected participants to cooperate more in the gain domain than in the loss domain (Hypothesis 4).

3.4.1. Method

3.4.1.1. Participants. Initially, 196 university students (134 women, 62 men) between the ages of 17 and 58 (*M* = 20.08, *SD* = 4.14) participated in this experiment. Four students were excluded from the final analysis due to a technical error in recording their responses in Round 3 of the 5th supergame. However, their responses are available in the OSF (https://osf.io/7bsau/). Our final data consisted of 192 university students (130 women, 62 men) between the ages of 17 and 58 (*M* = 20.10, *SD* = 4.18) who participated in this experiment (for sociodemographic characteristics, see Appendix B - Table B.1). Inclusion criteria were the same as previously reported in Experiment 1, and participants were naïve concerning the experimental procedure. Therefore, participants who participated in Experiment 1 were not eligible for this experiment. As in the previous experiment, written consent was obtained from all participants. The Ethics Committee approved the experiment. The majority of participants received course credit in return for participation; however, nine students did not meet the criteria to receive the credit courses. Yet, they were interested in participating (two were Ph.D. students, four were law students, one was an Interuniversity Master's student, and the last one was a clinical physiology student). As in Experiment 1, two randomly selected participants received a monetary bonus payment in the form of a gift card proportional to the points gained in a random supergame played in the game task.

3.4.1.2. Materials. Materials were the same as the ones applied in Experiment 1.

3.4.1.3. Procedure. This experiment followed the same procedure as the first experiment conducted. Specifically, the experiment was a 2 (Type of game: DPD vs. SPD) × 2 (Time manipulation: forced time delay vs. time pressure) x 2 (Frame type: gain vs. loss) between-subject design. However, participants played a repeated version of the games in this experiment. The data gathering was performed using the same software as in Experiment 1. The experiment was conducted in groups of 4 participants, each participant arrived at the laboratory, and the group was subsequently allocated randomly to one of

the experimental conditions. Before starting the experiment, participants were directed to one computer station, separated by barriers, and responded to a sociodemographic questionnaire. Then, they read the rules and received training regarding the structure of the PD they would play in the game task to guarantee that participants comprehended the different possible outcomes of the game (using the same method applied in the first experiment). Similar to Experiment 1, participants were instructed that two random participants would receive a gift card from a specific store with a payment proportional to the points earned. However, in Experiment 2, this was based on the final points accumulated from a random supergame they played.

Following the procedure implemented by Costa et al. (2022) and Gong et al. (2009), participants played a supergame with the same partner, and each supergame involved a sequence of ten rounds. Since participants played ten supergames, they made a total of 100 decisions. They played each supergame against the same opponent and then randomly changed opponents for the next supergame. During the game, participants knew they would play ten rounds in a supergame with other players but did not know how many supergames they would play. The game structure of the four games was similar to Experiment 1. Every time a new supergame begins, it starts a new interaction, and in the case of a loss frame, at the start of each supergame, each player received 1500 points, which they used to determine if they want to invest. The objective of each participant was to stay with the maximum points possible at the end of each supergame; in this case, they had to lose the minimum points possible. Each participant decided if they wanted to invest to prevent a more substantial loss. Both players do not incur in a larger loss if only both have decided to cooperate (i.e., invest). However, in the gain frame context, each player started the supergame with zero points, and the objective was to make the most points possible in the ten rounds they would play. The total number of points gathered at the end of the tenth round was not carried over from one supergame to the next one. Time manipulation instructions were applied in the same method as in the first experiment.

Before starting the game task, participants received information about the supergame. Then, the number of the supergame appeared on the screen for 3 seconds, indicating that the task or a new interaction would begin. In the decision screen, each participant was informed that the other player was also facing the same decision problem. After participants had decided, they were instructed to wait if the other player was still deciding – in a waiting screen. When both participants made their decisions, they received feedback regarding the decision both made and the total payoffs both had gathered until that moment. After seeing the feedback, participants clicked on continue to start a new round. However, the round only started when all participants saw the feedback and pressed to continue the experiment.

After completing the game task, participants responded to the SVO and BART tasks. Finally, participants responded to the PANAS-SF, game-related questionnaire, and IRI. A session, including the game task and the questionnaires, lasted approximately 50 minutes in the time pressure condition and about 60 minutes in the forced time delay condition.

3.4.2. Data Analysis

To explore participants' learning effects across rounds and different conditions, we performed a time series analysis of the mean cooperation. Additionally, we conducted a Generalized Linear Mixed Model (GLMM) analysis to evaluate the effects of time manipulation, type of game (stochastic vs. deterministic), and type of frame (gain vs. losses) on participants' likelihood to cooperate. We also addressed the moderator effect of the interaction between the SVO with time manipulation and risk-taking propensity with the three variables of the game. The dichotomic choice between cooperation or defection was entered as the dependent variable in a GLMM analysis with by-subject random intercept and slope for the different rounds and supergames. Multilevel modeling was chosen to account for the fact that the choice data is nested.

To verify if there was an initial intuitive propensity to cooperate, we tested whether the cooperation rate in the first round of each supergame was higher than in the subsequent rounds for the time pressure condition compared to the forced time delay. Thus, we also used a GLMM, but in this case, with cooperation rate as the dependent variable and round (cooperation in the first round of each supergame vs. mean cooperation of subsequent rounds in each supergame) and time manipulation (time pressure vs. time delay) as fixed main terms, as well as their interaction fixed effect. The supergame was entered as a random effect to control for the fact that participants played ten supergames.

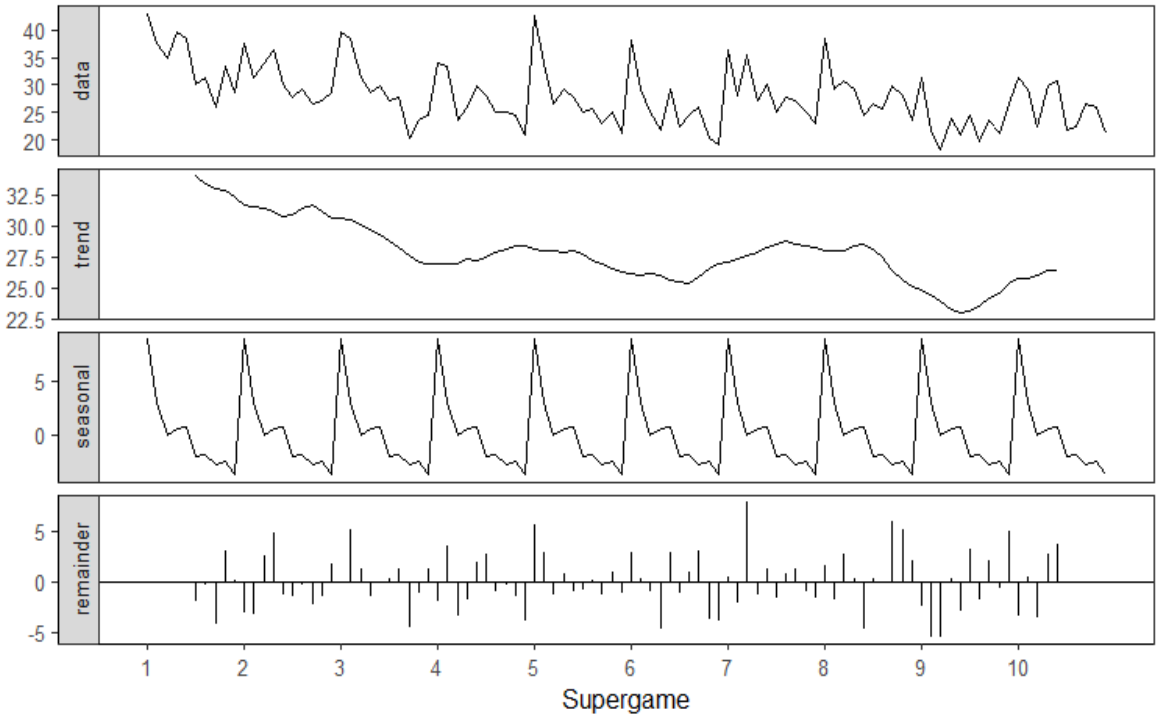
Similar to Experiment 1, we added the full summative model in Appendix B.3., including all predictors and their interactions. In this model, we added sociodemographic (e.g., gender and socioeconomic level), individual characteristics (e.g., empathy and mood previous to the start of the task), inherent task aspects (e.g., difficulty, pleasantness, proximity, daily cooperation with the other players) as covariates. Finally, we also presented another model with the addition as a covariate of other past decisions (see Table B.3.2). Statistical analyses were performed using R (R Core Team, 2021) and RStudio (RStudio Team, 2021; Version 1.4.1103). The analysis code, data, and materials are accessible at OSF (https://osf.io/7bsau/).

3.4.3. Results

3.4.3.1. Time-Series Analysis. The mean proportion of cooperative choices per round and supergame, as well as the decomposition of the series as a combination of level, trend, seasonality, and residual components, are presented in Figure 10. Visual inspection suggests a sharp decline in cooperation in early rounds and an overall negative trend with a seasonal pattern every ten rounds.

Figure 10

Decomposition of Additive Time Series as a Combination of Level, Trend, Seasonality, and Residual Components



We performed a time series analysis to characterize changes in cooperation over the 100-round sequences. We selected the best-fitting autoregressive integrated moving average (ARIMA) (p, d, q) model (Box & Jenkins, 1976). The "p" parameter is attributed to the autoregressive part of the model and expresses the number of past observations (lag). The differencing parameter, "d", represents how often the raw observations are differenced to make the time-series stationary (constant mean, variance, and autocorrelation). The moving average part of the model implies that the future error is a linear combination of respective past errors, with window size "q". The general ARIMA model is expressed as follows:

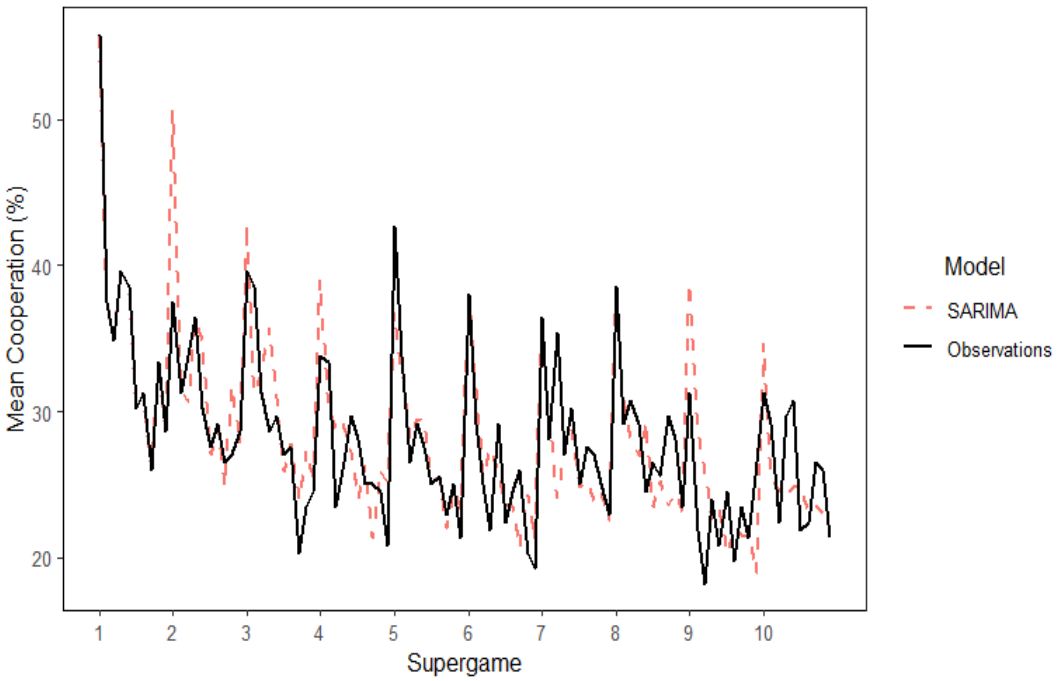
$$\hat{y}_t = \mu + \phi_1 y_{t-1} + \cdots + \phi_p y_{t-p} - \theta_1 e_{t-1} \cdots - \theta_q e_{t-q}$$

where, $\hat{y}_t$ is the predicted value at time t, μ the constant, ϕ the autoregressive parameters of order p, θ the moving average parameters of order q, y_{t-p} the lagged values of y, e_{t-q} the lagged errors.

Identification of suitable ARIMA models was performed by analyzing the autocorrelation and partial autocorrelation plots and with the help of the function "auto.arima" (Hyndman & Khandakar, 2008) available in the R forecast library (Hyndman et al., 2023). This function automatically selects the best model by using an algorithm that searches for the lowest AIC. The best fitting model (*AIC* = -316.8), which met Ljung-Box criteria of independence of residuals (Ljung–Box Q(17) = 16.45, p = .49), was a Seasonal ARIMA - SARIMA(1,0,1)(0,1,1,10) and showed a root mean squared error (RMSE) of 0.036 (Figure 11). SARIMA(p,d,q)x(P,D,Q,s) models are ARIMA(p,d,q) models with a seasonal component (P,D,Q,s), where "P" denotes the seasonal autoregressive part of the model, "D" the number of seasonal differences, "Q" the combination of seasonal past errors, and "s" the seasonality (e.g., s = 10 rounds). The model shows that a seasonal difference is needed to make the series stationary, which suggests a cooperation pattern across supergames. Also, the autocorrelation at lag 1 implies that cooperation in each round is influenced by the cooperation in the previous round.

Figure 11

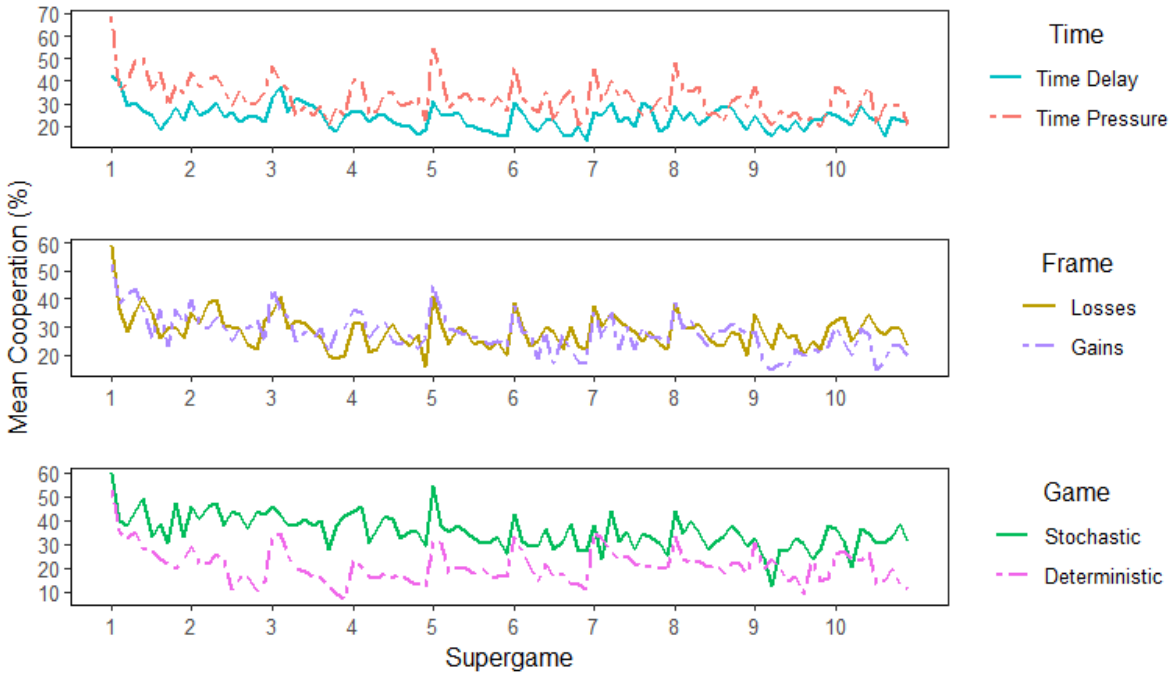
Observed Cooperation vs. Fitted SARIMA(1,0,1)(0,1,1,10)



Additionally, we explored the cooperation strategies for the different conditions (Figure 12). Visual inspection of the time-series for the multiple conditions suggests, as previously reported for the overall cooperation, a seasonal pattern every ten rounds, a negative trend with a sharp decline in cooperation during the first supergame, except for the stochastic condition where cooperation appears to have a slower decay rate.

Figure 12

Cooperation for the Different Conditions



Time manipulation

The cooperation in the first round for the time delay condition (42%) is much lower compared to the time pressure condition (69%) and remains generally lower for the remaining trials. The SARIMA(1,1,1)(1,0,0,10) (*AIC* = -337.46; *RMSE* = .04, Ljung–Box *Q*(17) = 20.04, *p* = .27) fitted to the mean cooperation in the time delay condition suggests that when people have more time to make judgments, they take into account not only their previous choice but also their choice in the previous supergame, which seems not to occur in the time pressure condition: SARIMA(0,1,1)(0,0,2,10) (*AIC* = -243.99; *RMSE* = 0.07; Ljung–Box *Q*(17) = 14.53, *p* = .63).

Frame manipulation

The time-series analysis of the type of frame suggests that there are no observable differences in cooperation between the gains and losses conditions. The SARIMA(3,1,0)(1,0,1,10) (*AIC* = -296.32; *RMSE* = 0.05; Ljung–Box *Q*(17) = 8.71, *p* = .89) fitted to the mean cooperation of the gain-frame suggests that participants' cooperation at each round was autocorrelated with their cooperation up to three previous rounds and the choice in the previous supergame, in contrast to the loss-frame: SARIMA(0,1,1)(0,0,2,10) (*AIC* = -289.05; *RMSE* = .05; Ljung–Box *Q*(17) = 12.57, *p* = .76), suggesting that cooperation in the loss-frame is not autocorrelated with previous decisions.

Game manipulation

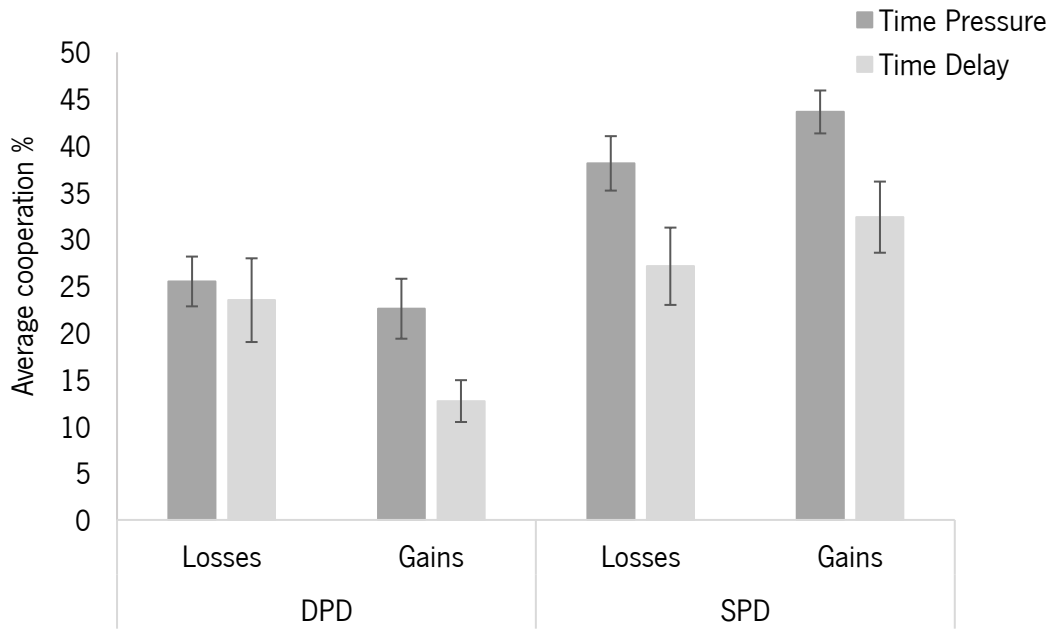
The visual inspection of the time-series for the game type manipulation shows that despite the similar initial cooperation between the stochastic (58%) and the deterministic game (52%), cooperation in the deterministic paradigm suffers a sharp decline and, overall, remains much lower than cooperation in the stochastic condition, which has a slower decay. SARIMA(0,1,1)(0,1,1,10) (*AIC* = -292.35, *RMSE* = .04, Ljung–Box $Q(18) = 20.77$, $p = .29$) fitted to the cooperation in the deterministic condition shows that a seasonal and a non-seasonal difference were needed to make the series stationary, suggesting that in addition to the negative trend, participants exhibited a regular pattern for each supergame. The SARIMA(0,1,1)(1,0,0,10) (*AIC* = -270.39, *RMSE* = .06, Ljung–Box $Q(18) = 14.72$, $p = .68$) fitted to the stochastic observations suggests that participants' cooperation at round *n* is influenced by their decision at round *n* of the previous supergame.

Overall, our results show that cooperation has a negative trend with a regular pattern that recurs every supergame for each of the different conditions. Specifically, our data suggest that participants relied more on their past decisions when they had more reasoning time. Moreover, cooperation in the stochastic version of the game showed a slower decay rate, suggesting a slower learning process.

3.4.3.2. Logistic Regression for the Likelihood of Cooperation in the Repeated Game. We conducted a generalized logistic regression model to determine the effects of uncertainty, type of frame, and time manipulation on participants' likelihood to cooperate. In this regression model, we fitted the model with the game variables and the moderator's effects of the SVO and risk-taking propensity (see Table 13). Figure 13 shows the average cooperation rate from the analyses of the 100 decisions made. Cooperation rates appear higher in the SPD in both decision time manipulation (see Figure 14 for more detail). Additionally, participants in the time pressure condition appear to be more cooperative than in the forced time delay condition.

Figure 13

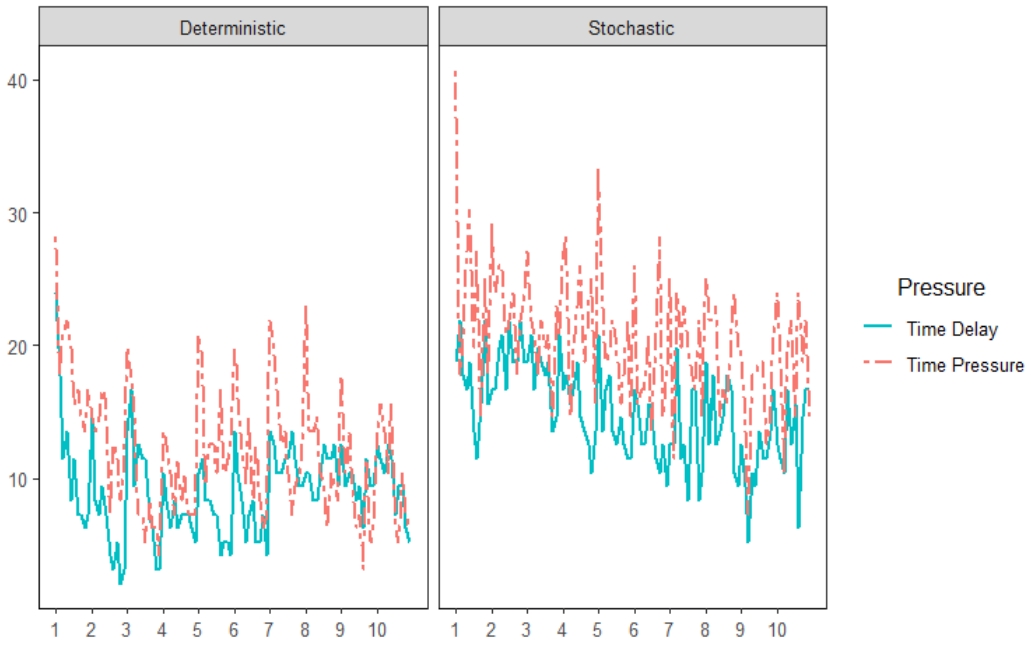
Average Cooperation Rates (Average Proportion of Times Participants Invested) in a Repeated Game Across Conditions



Note. n = 24 participants in each condition presented. Error bars represent standard errors of the mean.

Figure 14

Average Cooperation Rates in the Interaction Effect Between the Type of Game and Time Manipulation



Note. n = 48 participants in each condition presented.

The model revealed a significant main effect of the time manipulation (β = 0.72, z = 6.83, p < .001, OR = 2.06, 95% CI [1.67, 2.53]), indicating that participants were slightly more prone to cooperate under time pressure (32.5%) than under a forced time delay (23.9%). Furthermore, results showed a significant effect of the type of game (β = -0.68, z = -6.74, p < .001, OR = 0.51, 95% CI [0.41, 0.62]); participants were more cooperative in the SPD (35.3%) than in the deterministic game (21.1%). In addition, there was a significant main effect on the type of frame (β = 0.21, z = 2.05, p = .041, OR = 1.23, 95% CI [1.01, 1.50]), such that participants seemed to cooperate more in a context of gains than in a context of losses.

Additionally, data revealed a significant interaction effect between the type of game and time pressure manipulation (β = -0.36, z = -3.90, p < .001, OR = 0.69, 95% CI [0.58, 0.83]). Post-hoc tests with Bonferroni correction revealed that participants in the SPD game cooperated significantly more than in the DPD game, both under time pressure (β = 0.79, z =17.27, SE = .05, p < .001, OR = 2.19, 95% CI [2.00, 2.40]) and under time delay conditions (β = 0.75, z = 14.53, SE = .05, p < .001, OR = 2.11, 95% CI [1.91, 2.34]). Additionally, participants cooperated less under a time delay than under a time pressure condition in both an SPD game (β = -0.56, z = - 12.44, SE = .05, p < .001, OR = 0.57, 95% CI [0.52,0.62]) and a DPD game (β = -0.52, z =9.68, SE = .05, p < .001, OR = 0.59, 95% CI [0.53, 0.66]).

Results also revealed an interaction effect between the type of frame and type of game (β = -1.00, z = -9.71, p < .001, OR = 0.37, 95% CI [0.30, 0.45]). Post-hoc tests with Bonferroni adjustments showed that participants in the SPD cooperated less under a loss domain than in the gain domain (β =--0.14, z = -3.06, SE = .04 p = .009, OR = 0.87, 95% CI [0.80, 0.95]). However, the opposite effect was found in the DPD game participants cooperated more under a loss domain than gains (β =0.53, z = 10.09, SE = .05, p < .001, OR= 1.70, 95% CI [1.89, 1.54]). Furthermore, in the loss frame, cooperation rates were found to be higher in the SPD than in the DPD (β =0.43, z = 9.27, SE = .05, p < .001, OR = 1.54, 95% CI [1.41, 1.69]), and in the gain domain (β =1.10, z = 21.89, SE = .05, p < .001, OR = 3.01, 95% CI [2.73, 3.32]).

However, the results did not find an interaction effect between the type of frame and the time manipulation (β = -.04, z = .49, p = .622, OR =1.05, 95% CI [0.88, 1.25]). Regarding the triple interaction effect between the type of game, time manipulation, and the type of frame, results showed a significant interaction effect (β = .66, z = 4.75, p < .001, OR = 1.93, 95% CI [1.47, 2.53]). A contrast analysis between the three variables of the game with Bonferroni adjustments is presented in Appendix B.3. (for details see Figure B.3.1 and Table B.3.3). Generally, results revealed that participants were more cooperative under time pressure conditions and in the stochastic game, and they also cooperated more

under an SPD than a DPD game. In addition, results did not show differences in the loss vs. gain frame in the stochastic game under either time pressure or time delay. However, participants in the deterministic game under a time delay seemed to cooperate more under a loss than a gain frame.

Regarding the moderator effect of the SVO and risk-taking propensity, results revealed a significant main effect of the SVO (β = -0.44, z = -8.20, p < .001, OR = 0.65, 95% CI [0.58, 0.72]), showing that proselfs were less cooperative than prosocials. In addition, results showed an interaction effect between SVO and time manipulation (β = 0.50, z = 7.14, p < .001, OR = 1.65, 95% CI [1.44, 1.90]). Pairwise post-hoc tests with Bonferroni correction revealed that under time delay, prosocial individuals cooperated more than proself individuals (β = 0.44 z = 8.20, SE = .05, p < .001, OR = 1.55, 95% CI [1.39, 1.72]). However, results did not find a significant effect under time pressure between prosocial and proself participants (p = .589). Furthermore, findings showed that both prosocial and proself participants cooperated less under time delay than under time pressure, and the effects were significant for both groups (prosocial: β = -0.29, z = - 6.54, SE = .04, p < .001, OR = 0.75, 95% CI [0.69, 0.82]; proself: β = -0.79, z = - 14.25, SE = .06, p < .001, OR = 0.45, 95% CI [0.41, 0.51]).

Results also revealed a significant main effect of the risk-taking propensity (β = 0.01, z = 3.06, p =.002, OR = 1.01, 95% CI [1.00, 1.01]), indicating that risk-takers were more cooperative. Also, there was a significant interaction effect with time manipulation (β = -.02, z = -5.85, p < .001, OR =0.98, 95% CI [0.98, 0.99]), such that under time pressure, risk-taking individuals cooperate less. A significant interaction effect was also found between risk-taking propensity and the type of game (β = .02, z = 5.84, p < .001, OR =1.02, 95% CI [1.01, 1.02]), such that in a deterministic game, risk-taking cooperate more. However, results did not find a significant interaction effect with the type of frame (β = -.00, z = -1.24, p =.217, OR =1.00, 95% CI [0.99, 1.00]).

Concerning the round and supergame, there is a significant negative effect of the round (β = -0.06, z = -9.51, p < .001, OR = 0.94, 95% CI [0.93,0.95]) and a significant negative effect of the supergame (β = -0.04, z = -3.75, p < .001, OR = 0.96, 95% CI [0.94, 0.98]), suggesting that participants decreased their cooperation rates over time. We also addressed round and supergame as factor variables, and the results were similar to the first model (for the generalized regression model with supergame and round as factors, see Table B.3.1.). In addition, results demonstrated a learning effect such that cooperation rates decrease as the number of rounds and supergame increases. The model's total explanatory power with the random effects is moderate (conditional R^2 =.099), and the section of the model related to the fixed effects alone is also moderate (marginal R^2 = .095).

Table 13

Estimates of the Logistic Regression for Cooperation Probability in the Repeated PD Game

				95 % CI for odds ratio		
	β (SE)	*Z* value	*p*	*LL*	Odds Ratio	*UL*
Intercept	-.39(.11)	-3.43	.001	.54	.68	.85
Game [DPD]	-.68(.10)	-6.74	<.001	.41	.51	.62
Time [Pressure]	.72(.11)	6.83	<.001	1.67	2.06	2.53
Frame [Gain]	.21(.10)	2.05	.041	1.01	1.23	1.50
Game*Time	-.36(.09)	-3.90	<.001	.58	.69	.83
Game*Frame	-1.00(.10)	-9.71	<.001	.30	0.37	0.45
Frame*Time	.04(.09)	.49	.622	.88	1.05	1.25
Time*Frame*Game	.66 (.14)	4.75	<.001	1.47	1.93	2.53
Round	-.06 (.01)	-9.51	<.001	.93	.94	.95
Supergane	-.04 (.01)	-3.75	<.001	.94	.96	.98
SVO[Proself]	-.44 (.05)	-8.20	<.001	.58	.65	.72
SVO[Proself]* Time	.50 (.07)	7.14	<.001	1.44	1.65	1.90
Adjusted Values Bart	.01 (.00)	3.06	.002	1.00	1.01	1.01
AdjustedBart*Time	-.02 (.00)	-5.85	<.001	.98	.98	.99
AdjustedBart*Game	.02 (.00)	5.84	<.001	1.01	1.02	1.02
AdjustedBart*Frame	-.00 (.00)	-1.24	.217	.99	1.00	1.00
N	19200					
AIC	21744.2					
BIC	21893.6					
Log-likelihood	-10853.1					

Note. β = coefficient; *SE* = Standard Error of the coefficient; *CI* = confidence interval; *LL* = lower limit; *UL* = upper limit; AIC = The Akaike information criterion; BIC = Bayesian information criterion.

3.4.3.3. Generalized Linear Mixed Models. We fitted a generalized linear mixed model to investigate whether the cooperation rate differed between the first round and subsequent rounds in the supergame under time pressure compared to forced time delay. The model included supergame as a

random effects variable. The GLMM demonstrated a significant effect of the time manipulation (β = -0.31, *SE*=0.04, t = -8.17, p < .001), indicating a decrease in cooperation under time delay compared to time pressure condition. Results also revealed a significant effect of the round; there is a decrease in cooperation in the subsequent rounds compared to the cooperation in the first round (β = -0.28, *SE*= 0.04, t = -7.33, p < .001).

Additionally, we found an interaction effect between time manipulation and round (β = 0.12, *SE*= 0.02, t = 4.86, p < .001). Posthoc test using Bonferroni correction revealed that in the first round, there is an interaction effect between the time delay and the time pressure condition (β = -0.19, *SE*=0.02, *t(27)*= -11.41, p < .001), suggesting that cooperation decrease under forced time delay in the first round. In the subsequent rounds, the Posthoc test also revealed a significant effect between the time delay and the time pressure condition (β = -0.08, *SE*= 0.02, t(27)= - 4.52, p < .001) such that cooperation decreased under forced time delay. Additionally, a significant effect was found in the time pressure condition between subsequent rounds and the first round (β = -0.16, *SE*= 0.02, t(27)= -9.51, p < .001). In the first round, participants cooperated more than in the subsequent round, suggesting an initial intuitive propensity to cooperate. In addition, we found a marginally significant effect in the time delay condition between the first and subsequent rounds (β =- 0.04, *SE*= 0.02, t(27)= - 2.63, p = .056).

3.4.4. Discussion

In the second experiment, we analyzed a repeated game, given the importance of studying the learning effects on cooperation in games with and without stochastic payoffs and the impact of time manipulation. Regarding the effect of time manipulation, results are consistent with our first hypothesis, suggesting that participants tend to be more cooperative under time pressure than under time delay conditions. Based on previous research findings (Everett et al., 2017; Isler et al., 2021; Isler et al., 2018; Strømland et al., 2018), we believe that introducing a gain frame and incorporating an assessment of task comprehension would have higher contribution rates across the game, contrary to our previous study (Costa et al., 2022). Additionally, our results support our second hypothesis, suggesting that there seems to exist an initial tendency to cooperate at the beginning of every supergame, and this effect increased under time pressure manipulation. These findings are also congruent with previous results by Gallotti and Grujić (2019), where they found an early intuitive bias toward cooperation in repeated games. Moreover, as the previous authors found, we confirmed an increase in cooperation after a short pause (Gallotti & Grujić, 2019).

In our third hypothesis, we expected participants to cooperate more in the DPD than in the SPD. The results found in this experiment showed the opposite effect using the same game structure, contradicting our hypothesis and previous literature (Gong et al., 2009; Kunreuther et al.,2009). Contrary to previous studies that use IDS games (Gong et al., 2009; Kunreuther et al.,2009), we applied a time manipulation procedure that might have affected cooperation patterns. In the present experiment, participants were randomly assigned to either a time pressure condition or a forced time delay condition. Moreover, in a previous study, we did not find a statistically significant effect between the type of game, but observed that participants tended to show more cooperation in the SPD than in the DPD (Costa et al., 2022). In order to determine whether our findings result from time manipulation, future research should include a control condition in which time is not manipulated. This will allow us to test if cooperation patterns across games follow previous literature (Gong et al., 2009; Kunreuther et al.,2009).

Our results suggested that participants cooperate more in the gain frame than in the loss frame, supporting our fourth hypothesis and previous findings (Everett et al., 2017). Additionally, we found an interaction effect between the type of game and the type of frame. Participants appeared to cooperate more under the losses than the gains frame in the deterministic game, whereas the opposite pattern emerged in the SPD, where participants seemed to cooperate more in a gain frame. Previous findings from Isler and colleagues (2021) have also found higher cooperation in provision dilemmas (similar to our gain domain) than in maintenance dilemmas (similar to our losses domain). Regarding the effect of time manipulations, their results revealed that deliberation increases defection in provision games (i.e., gains) but favors cooperation in maintenance games (i.e., losses). Their study suggested that this difference aligns with dilemma-specific intuitions, which tend to be more self-oriented in losses (Isler et al., 2021). These findings suggested that the prediction of the SHHs does not extend to loss dilemmas, but it is explained by SCA, such that individuals under intuition are more selfish (Isler et al., 2021). Our results seem to align with these authors' conclusions for the DPD game under forced time delay, where participants cooperated more in the loss frame than in the gain frame. Nevertheless, we did not find a significant interaction effect of the type of frame and time manipulation. In our study, participants always exhibited higher cooperation under time pressure than in a forced time delay condition.

In addition, in deterministic and stochastic games, participants exhibited decreased cooperation over time, and this finding supports previous research on repeated games (Bereby-Meyer & Roth, 2006; Costa et al., 2022; Gong et al., 2009; Kunreuther et al., 2009). Through our analyses, we observed that participants learned to cooperate more in the early rounds, whereas they showed less cooperation in the final rounds of the supergame, thus supporting previous findings (Bereby-Meyer & Roth, 2006; Costa et

al., 2022). In the SPD, as in Bereby-Meyer and Roth (2006), our data also indicated a reduced learning rate from one supergame to the next, supporting the hypothesis that partial reinforcement slows learning rates. Our data reveals that participants initially exhibit a higher level of cooperation in the stochastic condition and gradually learn to refrain from cooperating in each supergame at a slower pace than the deterministic game. These results are consistent with those of Bereby-Meyer and Roth (2006) for both repeated and non-repeated games. However, the cooperation pattern present in our experiment revealed a similar pattern to the results for non-repeated games in Bereby-Meyer and Roth (2006). Specifically, in our deterministic game, participants learn faster not to cooperate over time, while in stochastic games, participants exhibit higher cooperation in the beginning and learn more slowly not to cooperate. In the repeated games of Bereby-Meyer and Roth (2006), participants in the first periods cooperate less in the stochastic games than in the deterministic condition, they then learn not to cooperate more slowly than participants in the deterministic condition.

Results also found a significant effect of the type of game and time manipulation, indicating that participants in the stochastic and deterministic game cooperated more under a time pressure condition than in the forced time delay condition. The time series analysis suggests that participants relied more on their past decisions when they had more time for reasoning. These results are similar to those found by Duffy and Smith (2014), where the authors found that under a low cognitive load, participants rely more on the outcomes of previous rounds. Evidence from repeat interactions also suggested that under time pressure, participants are less able to base their behavior on the previous choices of other group members (Goeschl & Lohse, 2018). In addition, previous research has revealed that cooperation in repeated games is motivated mainly by strategic concerns (Dal Bó & Fréchette, 2018; Dreber et al., 2014). As in Duffy and Smith (2014), our results also suggested that participants in both treatments tended to the Subgame Perfect Nash Equilibrium behavior at the end of each supergame, particularly under a forced time delay.

Furthermore, consistent with our first experiment's results, participants exhibited a higher cooperation rate in the stochastic game under the time pressure condition. Recent research by van den Berg et al. (2021) manipulated participants' uncertainty regarding the consequences of helping others, ranging from complete certainty to partial uncertainty (i.e., the consequence of helping lay in some range) to complete ambiguity. Results revealed that under uncertainty, participants helped their interaction partners more often than in conditions with less uncertainty. Participants interpreted the uncertainty range using a simple solution: they used the measure of the center of the uncertainty range as the real consequence of helping. When participants did not know which of the possible scenarios would unfold,

they seemed to select the one that appeared more typical. The authors attributed these findings to participants' use of social heuristics (van den Berg et al., 2021). Because participants who had to deal with uncertainty used a heuristic, they ended up helping more frequently than their counterparts.

Another justification that future research should consider is that participants under uncertainty may cooperate when making fast decisions to avoid conflicts (Jarke-Neuert & Lohse, 2022). In our experiment on stochastic games, mutual cooperation could also avoid conflict since there is no uncertainty regarding the results when using this strategy (i.e., results are not a consequence of a lottery). Previous research has also shown that decision-makers under time pressure tended to adopt more uncomplicated strategies and always maintain an identical strategy if adjusting it would result in more cognitive costs (Ordóñez et al., 2015). Another possible explanation for our results in the SPD game under time pressure could be found when considering the literature on risky decisions with binary lotteries and time pressure. Our results in SPD seem consistent with the studies that found that participants were more risk-aversive under time pressure manipulation (Ben-Zur & Breznitz,1981; Gawryluk & Krawczyk, 2019). However, this conclusion could only be made if participants in our study judged the option of cooperation in the SPD as more risk-aversive.

Moreover, findings from our experiment suggest that intuition promoted cooperative behavior, but it also revealed that intuition interacts with individual characteristics. Results from individual characteristics such as the SVO showed that prosocial individuals cooperate more than proselfs. Similar to the findings of Alós-Ferrer and Garagnani (2020), prosocial individuals cooperate more under time-pressure conditions – even though we also found that proselfs also cooperate more under time pressure. Our findings did not find significant differences in cooperation rates between prosocial and proself individuals under time pressure. Even so, proselfs cooperate less than prosocial under a forced time delay condition.

Similar to previous studies (Fung et al., 2012; Parks, 2004), we discovered a significant effect of risk-taking propensity on cooperative decisions, suggesting that participants with higher scores on risk-taking propensity tended to cooperate more. Furthermore, we contributed to the literature by demonstrating that risk-taking propensity interacts with time manipulation and the type of game. Results revealed that individuals with high risk-taking propensity cooperated less under time pressure than under a forced time delay. Similarly, participants with a higher risk-taking propensity tended to cooperate less in a stochastic game than in a deterministic game. In the SPD, risk-taking individuals are more inclined to choose the option that could lead to probabilistic payoffs since mutual cooperation in SPD games leads to certain outcomes for both players. As in the experiment conducted by Alós-Ferrer and Garagnani

(2020), we conclude that it is essential to study the influence of individual behavior on time manipulations, as the results of each experiment depend on the recruited sample, particularly regarding the prevalence of specific predispositions, such as prosociality and risk-taking propensity.

This experiment addresses crucial questions regarding the ability to learn in repeated games and the relationship between intuition and individual differences. In summary, our findings suggested the presence of a learning process, as participants learned not to cooperate over time, and revealed a slower learning pattern in the SPD. In addition, participants in the stochastic game exhibited higher levels of cooperation than those in the deterministic condition.

3.5. General Discussion

The primary goal of this study was to explore the effect of cognitive processing on cooperation under different contexts involving risk and uncertainty. Therefore, we conducted two experiments: a one-shot and a repeated PD. In both experiments, we manipulated the time available to make a decision (time pressure vs. forced time delay), the game type (stochastic vs. deterministic), and the frame type (gains vs. losses).

Our results supported the SHH (Rand, 2016), revealing that time pressure manipulation favors cooperation. Additionally, in the repeated version of the game, cooperation under time pressure was significantly higher in the initial round of each supergame than in the subsequent rounds (similar to Gallotti & Grujić, 2019 findings). We extended previous work on the SHH (Capraro, 2023; Rand, 2016), showing that time pressure manipulation favors cooperation in games with stochastic payoffs.

In both experiments, participants seem to cooperate more in the stochastic game than in the deterministic game under time pressure. These findings align with recent literature (van den Berg et al., 2021), suggesting that individuals rely more often on social heuristics and cooperate more under uncertainty. Another possible explanation is that participants in the stochastic game may cooperate more under time pressure to avoid conflicts (Jarke-Neuert & Lohse, 2022) or tend to implement more simple strategies (Ordóñez et al., 2015). Mutual cooperation in the stochastic game can be perceived as a more simplistic option since it does not present for both players a probabilistic outcome. Results from both experiments seem to suggest that participants cooperate more and risk less under time pressure than participants under a forced time delay. Previous research has demonstrated that participants tend to maintain the same strategy if adjusting it would increase cognitive costs (Ordóñez et al., 2015).

Furthermore, results from the repeated game demonstrate a learning process, as participants learned with experience to cooperate more in the early rounds and less in the final rounds of the

supergame. Specifically, in the SPD, participants exhibited slower learning from one supergame to the next, supporting the hypothesis that partial reinforcement slows down learning (Bereby-Meyer & Roth, 2006). Our experiment also found evidence that cooperation in repeated games is motivated by strategic considerations (Dal Bó & Fréchette, 2018; Dreber et al., 2014) since participants tended to the subgame Nash Equilibrium (defect, defect) in the last round of each supergame (Duffy & Smith, 2014), and participants relied more on their past decisions when they had more time for reasoning.

Consistent with a previous study conducted by Alós-Ferrer and Garagnani (2020), results from our repeated games suggested that individual characteristics play a role in promoting default behavior in a cooperation context. However, we did not find this result in the one-shot game experiment. A limitation of our study and Alós-Ferrer and Garagnani's (2020) study is that the interaction effects of the individual characteristics are correlational. That is, we did not directly manipulate these variables in the experiment. Another limitation of our study is that it provides evidence supporting the SHH in a context where it should be easier to observe its validity. More specifically, the study was applied in a cooperative and trusting environment of a WEIRD (i.e., western, educated, industrialized, rich, and democratic) university campus (Henrich et al., 2010), where most of the population were female students. Future research should explore the effects of time pressure on uncertainty and losses to other samples. Nevertheless, the evidence found for the SHH is important, considering the previous failed attempts (Bouwmeester et al., 2017; Camerer et al., 2018; Tinghög et al., 2013; Verkoeijen & Bouwmeester, 2014). With our study, we demonstrated that the SHH is valid, but its domain of applicability is contextually restricted, including relatively uncertain contexts and gain contexts.

Regarding the manipulation of time limits on cooperation, we used the forced time-delay method to promote cognitive reflection. However, two recent studies have revealed that only time-pressure manipulation affects cognitive performance and that the time-delay condition functions merely as a control (Isler et al., 2020; Isler & Yilmaz, 2022). Given the lack of effects of time delay conditions on the effective manipulation of deliberation, future studies should also use a more effective manipulation of deliberation (e.g., long debiasing training, as in Isler et al., 2020; Isler & Yilmaz, 2022). Considering this, it would be critical to investigate the effects of intuition and deliberation under uncertain situations through other types of cognitive process manipulation (e.g., the two-response paradigm; Capraro,2023). One methodological limitation of the two experiments presented was the lack of a control condition (i.e., no information regarding decision time; Everett et al., 2017; Isler & Yilmaz, 2022). Addressing this question would be important for future studies because it is difficult to determine whether our results are due to the activation of intuitive or reflective processes without a control condition (Everett et al., 2017; Isler et

al., 2020; Isler & Yilmaz, 2022). As previously mentioned, using a control condition would also be necessary to clarify if the effects found in the type of game are due to time manipulation.

Another limitation of this study could be the small sample size obtained when analyzing the interaction effect, specifically when analyzing the interaction effects between the three variables manipulated in the game, where the sample size is even smaller (n =24). Still, it is essential to emphasize the consistency of results between the two experiments. In order to understand the importance of the sample size, we conducted a power analysis. However, since we have random effects in the second experiment analysis, we could only conduct power analyses for the first experiment. Following Alós-Ferrer and Garagnani (2020) power analyses comparing time pressure and time delay in logistic regression, for a power of 0.80 given a medium effect size, it would be required a minimum of 45 participants for each condition. For the power analysis of the time pressure vs. forced time delay in our first experiment, we had a sample size of n =96 per condition, and using the z test in G*Power (Faul et al., 2009) with α= 0.05, we had a power of 0.99. Since we had several groups, we decided to conduct a power analysis following Everett et al. (2017) suggestion, assuming the percentage of cooperation obtained in our experiments, setting α= 0.05, and using our sample sizes, we conducted five power analyses. Regarding the effects of time pressure vs. forced time delay constrained to the loss frame conditions, we obtained a power of 0.90. Second, for the effects of time pressure vs. forced time delay constrained to the gain frame conditions, we obtained a power of 0.94. Third, for the effects of time pressure vs. forced time delay constrained to the stochastic condition, we obtained a power of 0.99. Fourth, for the effects of time pressure vs. forced time delay constrained to the deterministic condition, we obtained a power of 0.61. Finally, for the effects of time pressure vs. forced delay restricted to the stochastic and loss frame condition (n =24), we obtained a power of 0.94.

Another aspect to consider is the prize designated in the present study. Since participants were unaware of the total number of participants who completed the experiment, they might feel that the prize is very challenging to achieve as it depends on several factors. As a result, participants may perceive that their individual answers were not relevant or critical to obtaining the final prize. Therefore, future research should consider attributing a monetary prize to one participant within each of the four groups to enhance competitiveness. Additionally, future research should strive to understand if intuition promotes cooperation independently of individual characteristics or if it enhances intrinsic predispositions (Alós-Ferrer & Garagnani, 2020). Besides the importance of studying the interaction effect of intuition with individual predispositions, this line of investigation should also systematically investigate whether there are significant individual differences in response to uncertainty in a cooperative game (van den Berg et

al., 2021). Furthermore, we should analyze whether individuals cooperate differently if all strategic possibilities in a PD have payoff probabilities outcomes since, in the stochastic game we employed, mutual cooperation could be considered a risk-aversive decision. Thus, it would be important to analyze the interaction effect between time pressure and the SPD when all strategic payoff possibilities are uncertain or have an ambiguous payoff.

To summarize, this study contributed to the literature concerning the effects of time pressure manipulation on cooperation by exploring these effects in different contexts. Our results suggested that more than a default strategy, the social heuristic can be a deliberate strategy when uncertainty (concerning others, the results, or the ability to process complex information) is felt. In addition, we revealed that investigating the cognitive determinants of cooperative behavior requires accounting for individual differences, particularly when we analyze repeated games. We consider that studying why and when individuals cooperate within our society, simulating real-world scenarios full of risk and ambiguity while acting under time constraints, represents an important topic for future research.

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CHAPTER 4

Empirical Study 3:

A Dual-Process Approach to Prosocial Behavior Under COVID-19 Uncertainty

4. A Dual-Process Approach to Prosocial Behavior Under COVID-19 Uncertainty

This empirical work was adapted from the published work in the Journal of *PlosOne*. It was published under the Chicago style, but it was revised to the APA style 7th Edition for the dissertation.

Reference:

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In addition, results from this empirical work were presented in two scientific events:

Costa, D., Arantes, J., & Keating, J. (2020, November 19-22). *A dual-process approach to prosocial behavior in situations of uncertainty caused by COVID-19* [Poster presentation]. Virtual Psychonomic 61st Annual Meeting. Online, United States

Costa, D., Fernandes, N., Arantes, J., & Keating, J. (2021, May 6). *A dual-process approach to prosocial behavior in situations of uncertainty caused by COVID-19* [Virtual Conference presentation]. I Simpósio de Investigação Júnior em Psicologia [1st Junior Research Symposium in Psychology]. Online, Portugal

Analyses developed within this empirical study can be found at:
https://github.com/nunokf/Cooperation-under-Uncertainty-COVID-19/blob/main/index.md

Additionally, supplementary materials are presented in Appendix C.

4.1. Abstract

Uncertainty has been shown to reduce the willingness to cooperate in various social dilemmas and negatively affect prosocial behavior. However, some studies showed that uncertainty does not always decrease prosocial behavior, depending on the type of uncertainty. More specifically, recent research has shown that prosocial behavior tends to increase under impact uncertainty – uncertainty about the consequences for others if they become infected. In addition, researchers have argued that intuition favors prosocial behavior while deliberation leads to selfish behavior. Our study explored how intuitive (time pressure) or deliberate mental processing, under outcome, or impact uncertainty affect prosocial behavior in the context of the COVID-19 pandemic. Our sample consists of 496 participants, and we used a 4 (COVID-19 scenario: Control vs. Impact Uncertainty vs. Worst-Case vs. Indirect Transmission) by 2 (decision time: time delay vs. time pressure) between-subjects design. Results suggest that participants are more inclined to stay at home (prosocial intention) when forced to make their decisions intuitively rather than deliberately. Additionally, we found that uncertainty does not always decrease prosocial behavior. It seems that uncertainty does not affect the prosocial intention in a scenario with a real infectious disease. These findings suggest that the distinction between outcome and impact uncertainty may be due to the realism of experimental stimuli interventions.

Keywords: COVID-19; prosocial behavior; intuition; uncertainty

4.2. Introduction

With the emergence of the new SARS-CoV-2 virus, also known as Coronavirus Disease 2019 (COVID-19), we have become more conscious of how our actions and decisions can impact others' well-being. We make decisions that affect others in our everyday lives, and we can never be too certain about the impact of those decisions (Kappes et al., 2018).

The COVID-19 pandemic is one of the most significant health threats of the last century. At the moment, there have been more than 200 million confirmed cases of COVID-19, including 4.5 million deaths worldwide reported to the World Health Organization (WHO). The high spread of COVID-19 can be explained by asymptomatic individuals who are often unaware of being infected but still transmit the virus (Capraro & Barcelo, 2021; Mizumoto et al., 2020; Nishiura et al., 2020). Therefore, health professionals have recommended several measures to minimize the number of infections, including recommendations for people to stay at home (World Health Organization, 2021). At the beginning of the COVID-19 pandemic, many countries enforced lockdowns to slow Coronavirus spread. However, as case numbers diminished and the lockdowns lifted in May of 2020, many people believed the worst was surpassed and began socializing again without considering the protective measures. Although, at the end of 2020 and the beginning of 2021, several countries had to implement additional curfews, stay-at-home orders, and other measures to fight the new peaks of infections and deaths. For example, in New Zealand, anticipatory measures, such as lockdown and mandatory quarantine measures, helped combat the spread of COVID-19 (Mazey & Richardson, 2020). Reinforcing that, if countries impose a near-total lockdown where the population has minimal movement and interpersonal contact for several weeks, they can quickly return to the "new normal" where it can be removed several COVID-19 restrictions (Han et al., 2020; Mazey & Richardson, 2020). Removing restrictions does not mean returning to the pre-pandemic normal but instead deliberately transitioning to the "new normal" at the same time being ready to reinstate measures (Han et al., 2020). For example, daily life returned to the "new normal" even before the vaccination started in Singapore and New Zealand (Fakhruddin et al., 2020; Han et al., 2020).

Because it is difficult to monitor every individual activity, it is critical to understand how to communicate these measures and encourage individuals toward adopting prosocial behaviors (Bavel et al., 2020). In particular, appeals, messages, and news can effectively promote the desired behavioral changes because they can reach a large audience through mass media like television and social media (Bavel et al., 2020). However, when communicating these messages, policymakers, public health officials, and others should consider which messages effectively promote the acceptance of health measures against the Coronavirus (Capraro & Barcelo, 2020; Jordan et al., 2021; Kappes et al., 2018).

Health communication with the public has become even more important since, according to the WHO, the recent upsurge in noncompliance with COVID-19 protective measures is likely to be a product of Pandemic Fatigue (World Health Organization, 2020). Pandemic Fatigue has been defined as a "*demotivation to follow recommended protective behaviors, emerging gradually over time*" (World Health Organization, 2020, p.4).

Previous research in the field of health communication revealed that people are more risk-averse whenever their decisions affect others than themselves (Jordan et al., 2021). So, focusing on others' risks (rather than oneself) may be more effective in convincing individuals to practice public health behaviors (Bavel et al., 2020; Jordan et al., 2021). In a recent study, the authors found that prosocial framing is a more compelling message than self-interested framing to encourage people to embrace COVID-19 preventive behaviors (Jordan et al., 2021). Similar to previous findings, another study found that informing subjects that COVID-19 threatens "their community" increases the willingness to wear a face-covering mask (Capraro & Barcelo, 2020). However, in a replication study to the Japanese context, the authors found that all evaluated messages which emphasize the benefits of preventive behaviors for "*personal*", "*public*", "*personal and public*", or "*your family*" increased prevention intentions relative to a baseline (Miyajima & Murakami,.2021) In addition, in the last study Jordan and colleagues (2021) conducted, the authors noted that signaling together self-interested and prosocial framing may have been more effective than each in isolation.

Besides the importance of the messages conveyed, one should also consider the importance of individual differences for the embracement of prosocial behavior in the COVID-19 pandemic. Previous research has examined the relationship between preventive behaviors and self-reported risk, risk-aversion, empathy, personality, and prosociality (Campos-Mercade et al., 2021; Gächter et al., 2004; Müller et al., 2021; Petrocchi et al., 2021; Pfattheicher et al., 2020; Wise et al., 2021; Zettler et al., 2022).

4.2.1. Uncertainty and Prosocial Behavior

Infectious disease epidemics give rise to community uncertainty, as demonstrated by the recent public health emergencies, including Severe Acute Respiratory Syndrome (SARS), influenza A (H1N1), Ebola, and Zika (Hubner & Hovick, 2020). Likewise, moral decision-making during a pandemic typically involves uncertainty (Bavel et al., 2020). There are several uncertainties during the pandemic of COVID-19, such as if we are contaminated and if we will infect others.

In experimental economic games, uncertainty has been shown to reduce the willingness to cooperate and behave prosocially (Budescu et al., 1990; De Kwaadsteniet et al., 2007; Gustafsson et al.,

1999; Gong et al., 2009; van Dijk et al., 2004). There could also be a decline in prosociality in medical decisions due to individuals using the uncertainty about the social impact of their health behaviors as an excuse to implement more selfish narratives (Bavel et al., 2020; Exley, 2016; Haisley & Weber, 2010; Kappes et al., 2018) that enable them to preserve a positive self-image (Kappes et al., 2018). In addition, research suggests that people may be less willing to sacrifice for others' benefits when they are uncertain about the outcome (Garcia et al., 2020; Gino et al., 2016).

Although some studies tried to understand the negative effect of uncertainty on cooperation, recent research suggested that uncertainty does not always promote selfish behaviors (Kappes et al., 2018). In this study, the authors introduced a distinction between two types of uncertainty: outcome uncertainty (i.e., uncertainty if a decision will result in a specific outcome) and impact uncertainty (i.e., uncertainty concerning how the negative outcome will influence others' health; Kappes et al., 2018). In a series of seven studies and following previous studies, the authors found decreased prosocial behavior under outcome uncertainty (Kappes et al., 2018). In contrast, prosocial behavior increased under impact uncertainty in economic experimental games and hypothetical medical decisions concerning an infectious disease (Kappes et al., 2018). In their study regarding medical situations, participants read a hypothetical case of a contagious disease and later had to decide whether they would go to work while sick. Uncertainty was manipulated by modifying the participants' knowledge about the susceptibility of the people they might transmit the disease at work (Kappes et al., 2018). Results demonstrated that in the impact uncertainty and worst-case conditions, participants were found to be more likely to remain at home than in the control condition (Kappes et al., 2018). This study suggested that concentrating on impact uncertainty may encourage individuals to make sacrifices for others even when the outcome is uncertain (Kappes et al., 2018). Furthermore, this study utilized an implicit/explicit manipulation paradigm (Phillips & Cushman, 2017). In this paradigm, participants made two possibility judgments (the possibility/impossibility that co-workers are susceptible; and the possibility/impossibility of contaminating co-workers) presented either under time pressure (implicit condition) or without time constraints (explicit condition). Following their possibility judgment, participants revealed whether they would go to work or not according to the scenario presented (Kappes et al., 2018). In addition to the reported uncertainty effect, the authors also found that fewer participants who made implicit possibility judgments (time pressure) indicated they would go to work - prosocial behavior- than those who made explicit possibility judgments (Kappes et al., 2018).

4.2.2. The Dual-Process Approach to Social Decisions

Similar to the previous result, where participants in the time pressure condition were more likely to behave prosocially than participants in a time delay condition (Kappes et al., 2018), research has been conducted in recent years to explore this relationship (Capraro, 2019). Experimental manipulations of decision time are accounted for within the dual-process approach, which conceptualizes decisions as arising from a competition between intuitive ("automatic") versus deliberative ("controlled") cognitive processes (Capraro, 2019; Kahneman, 2011). Research on dual-process assumes the existence of two types of process: Type 1 and Type 2 (Capraro, 2019, De Neys & Pennycook, 2019, Evans, 2010; Evans & Stanovich, 2013). Type 1 processing is autonomous and makes minimal demands on working memory resources (Evans & Stanovich, 2013). In addition, Type 1 processes have other associated features as they tend to be fast, nonconscious, and not put a heavy load on central processing capacity, meaning they tend to be associative and automatic (Evans, 2010; Evans & Stanovich, 2013; Kahneman, 2011). In this definition, Type 1 processes give rise to intuitions (Evans, 2010; Kahneman, 2003; Thompson, 2014). Regarding Type 2 processing, responses are intervened by distinctive higher-order reasoning processes, as they rely on hypothetical thinking and working memory. This type of response is slow, sequential, and correlated with measures of general intelligence (Evans, 2010; Evans & Stanovich, 2013; Kahneman, 2011).

In a recent investigation, participants were exposed to messages without conscious guidance or intention to rely on their emotions or messages to rely on their reasoning to determine if it promotes intentions of using a face-covering mask (Capraro & Barcelo, 2021). The dual-process theories suggest that relying on emotions is typically related to Type 1 processing, whereas relying on reasoning is typically associated with Type 2 processing (Evans & Stanovich, 2013). Altogether, the three studies revealed that priming participants with the message to "*rely on their reasoning"* increases the choice to wear a face-covering compared to priming participants that were instructed to rely on their emotions (Capraro & Barcelo, 2021). Additionally, several researchers have used other techniques like time constraints, ego depletion, and cognitive load besides conceptual priming to activate Type 1 and Type 2 (for a review, see Capraro, 2019). One of these methods could be more effective at promoting face masks than conceptual priming, to rely on emotions. Hence, previous research suggests testing which cognitive manipulations best promote the use of face masks (Capraro & Barcelo, 2021).

Previous research regarding the cognitive mechanisms involved in cooperation through economic games manipulated cognitive processes, using priming and time constraints methods, suggest that the intuitive response is to cooperate (Cone & Rand, 2014; Rand, 2016; Rand et al., 2012; Rand & Kraft-

Todd, 2014; Rand et al., 2014). The reported effects lead to the Social Heuristics Hypothesis (SHH; Bear & Rand, 2016; Rand et al., 2014). The SHH assumes that typically successful strategies become automated as default responses over time (Rand et al., 2014). Individuals who generally interact in environments where cooperation is advantageous should be predisposed to cooperation even when it does not pay off (Capraro & Cococcioni, 2015; Jordan et al., 2015; Rand, 2016; Rand & Kraft-Todd, 2014).

4.2.3.The Present Study

Given previous suggestions to test which cognitive manipulations best promote prosocial behaviors (Capraro & Barcelo, 2021), the present study aims to empirically investigate the cognitive mechanisms underlying human cooperation by analyzing the impact of intuition on individual prosocial intention under uncertain situations caused by COVID-19. To the best of our knowledge, this study is the first to analyze the interaction between time pressure manipulation and prosocial intentions under a real case of uncertainty caused by a worldwide pandemic.

Consistent with previous SHH findings (Rand, 2016) and the results found in a hypothetical infectious disease scenario (Kappes et al., 2018), we first hypothesize that the prosocial intention will be higher under time pressure conditions than the condition without a time limit. In our second hypothesis, we expected that in decisions concerning the threat of COVID-19, the prosocial intention would be lower in the control condition than in the other two conditions, namely under impact uncertainty and in the worst-case scenario. Moreover, in our third hypothesis, we expect lower prosocial intention under an indirect impact scenario than in the control condition. Furthermore, we will explore how individual differences influence the decision to adopt protective measures during the COVID-19 pandemic. Our findings will contribute to understanding the determinants of prosocial behaviors and individual differences in health situations. Moreover, this study may provide important insights for encouraging individuals to adopt prosocial behaviors

4.3. Method

4.3.1. Participants

A total of 711 participants filled out the questionnaire for this study. However, 215 participants were eliminated from this initial sample as they did not complete the first main task. Therefore, our final sample consisted of 496 subjects (a detailed description of the sociodemographic variables are presented

in Appendix C -Table C.1). Data collection occurred in two different periods in 2020. The first phase consisted of 317 (63.9%) participants who responded to the questionnaire from April until May, and 179 (36.1%) participants who responded to the questionnaire in the second phase from October until November. Of the 496 participants, 122 (24.6 %) were males, and 374 (75.4%) were females, ranging in age from 18 to 61 years old (M = 26.11; SD = 9.31). The majority were Portuguese (n = 483; 97,4%), students (n = 262; 52.8%), and most participants (n = 209; 58.5%) reported having finished the 12th grade. Regarding socioeconomic status (SES), most participants (n = 324; 65.3%) report having a medium socioeconomic status. Most participants (n = 407; 81.8%) reported not having interrupted academic or work activity totally because of the pandemic and maintained their activity by working from home or online school (n = 309; 62, 9%).

Concerning COVID-19 variables, most participants (n = 283; 47.7%) report not doing quarantine or prophylactic isolation. Participants reported having left home on average 13 times since the begging of the prophylactic isolation. The reasons for leaving home corresponded to the government's exceptions in the state of emergency (e.g., going to the grocery store; pharmacy). Regarding the infection with the virus at the moment of the questionnaire, the vast majority (n = 485; 81.8%) reported not being infected, and most participants (n = 385; 77.6%) reported not having any family or friends infected with COVID-19. All participants gave their written informed consent, according to the Helsinki Declaration. The Ethics Committee for Research in Social and Human Sciences, of the University of Minho approved the study. There were no exclusion criteria. Participants were naive concerning the whole experimental procedure. None of the participants received any monetary compensation, and they were recruited through institutional email communication and online social networks (e.g., Facebook). Psychology students who responded in the second phase received credit courses for their involvement.

4.3.2. Materials

4.3.2.1. Sociodemographic Variables Questionnaire. Participants answered demographic questions regarding age, sex, nationality, profession, academic qualifications, and SES.

4.3.2.2. COVID-19 Questionnaire. Regarding COVID-19 questions, participants answered if, due to the COVID-19 pandemic, they completely interrupted their academic or work activity. Suppose participants answered no to the previous question. In that case, they must clarify if they stayed at home (e.g., working/studying) or did not alter their working routine. In addition, participants indicated: if they were or have been infected with the Coronavirus; if any of their family/friends were infected with COVID-19; if they were doing prophylactic isolation or quarantine; how many times they had left home during

prophylactic isolation/quarantine; what security and social measures they took during that period. Lastly, participants rate to what extent they believe that in the future, people would comply with the recommendations of the general health direction (such as social distancing, staying at home) on a scale ranging from 1 to 7, *"very unlikely"* (1) to "*very likely*" (7).

4.3.2.3. Interpersonal Reactivity Index (IRI; Davis, 1983; Limpo et al., 2010). This scale measures empathy and contains 24 statements about feelings and thoughts that the person may or may not have experienced. The instrument is divided into four subscales (each with six items), namely Perspective Taking (PT), Empathic Concern (EC), Personal Discomfort (PD), and Fantasy (F). Participants were inquired to point out how well each item described them on a 5-point Likert scale, from 1 to 5- "*It does not describe me well*" (1) to "*Describes me extremely well*" (5). The Portuguese validation presented an adequate internal consistency and good reliability of this instrument (Limpo et al., 2010; PT- Cronbach's $\alpha = 0.73$; EC - Cronbach's $\alpha = 0.76$; PD - Cronbach's $\alpha = 0.80$; F - Cronbach's $\alpha = 0.84$).

4.3.2.4. Probabilistic Discounting Task. Participants answered a probabilistic discounting task based on Jones and Rachlin's (2009) study. Probabilistic discounting (PD) refers to decreasing the subjective value of a reward due to reducing probability. Five probabilities, expressed as percentages (90%, 70%, 50%, 30%, and 10%), were presented in 10 increments of guaranteed money. This task consisted of 45 questions that appeared in a randomized order; we translated these questions to Portuguese and used euros:

"*Please choose which amount of money you would rather have for each line:*

A. $75 guaranteed or B. A [p]% chance of winning $75.

A. $70 guaranteed or B. A[p] %chance of winning $75.—Down To— A. $5 guaranteed or B. A[p]%chance of winning $75." (Jones & Rachlin, p. 63)

4.3.2.5. COVID-19 Risk Perception Scale. To evaluate COVID-19 risk perception, we applied the ten questions used in a previous study (Wise et al., 2021). Those questions measured the risk perception regarding infection likelihood and severity for multiple hypothetical 'average' people and the subject themselves (for example, the average person in the neighborhood, state, and country). Additionally, participants rate the perceived risk of transmitting the infection to another person and how badly that person would be affected. Finally, all items were rated using a visual analog scale ranging from 1 to 7, *"very unlikely"* (1) to "*very likely*" (7). We also questioned people about how badly they felt they had been personally affected by the pandemic on a 7-point Likert scale - *"Not badly"* (1) to "*Badly*" (7).

4.3.2.6. Social Value Orientation (SVO; Murphy, 2011). The paper-based SVO measure assesses social behavior. In this version, we used the six primary items. First, participants indicate the

allocation of points (imagined as money) that defines their most preferred joint distribution between themselves and another individual (via a forced choice of nine alternatives that vary in benefits to self vs. the other). Then, mean allocations for self and the other were calculated for the six items. The inverse tangent of these two means' ratios produced an angle representative of the participants' SVO index (Murphy, 2011). A greater SVO angle implies that the participant more often chose the option that maximized giving more to others, consistent with prosocial or altruistic behavior (Murphy, 2011).

4.3.3. Task

Similar to a previous study (Kappes et al., 2018), in the main task of this experiment, participants judged whether a given event was possible or not. To confirm that participants internalized the answers for possible (selecting the *"possible*" word) versus impossible (selecting the *"impossible*" word) judgments, they went through a training phase of 20 trials (as in Kappes et al., 2018). The words "possible" and "impossible" were shown ten times each randomly during the trial practice, and participants had to press the adequate key. Thus, to investigate differences in deliberative forms of modal cognition, we started by focusing on judgments of possibility (Phillips & Cushman, 2017). To do that, we asked participants to judge if two events were possible or impossible while manipulating the amount of available time for this judgment. These judgments were made based on one of the four scenarios presented to each participant:

Control

In the control scenario, participants were presented with the following situation:

> *"Considering the Coronavirus (SARS-CoV-2 – COVID-19) pandemic health situation, you can either be healthy or infected, with or without symptoms. The General Health Direction has warned that COVID-19 is very contagious, meaning that people you contact may get infected. However, you still feel able to work, and you really want to go to the office to finish a project that is important for your career* ".

Impact uncertainty

Participants read a similar scenario to the control scenario in the impact uncertainty scenario. However, additional information was added between the previous paragraphs about the vulnerability of people they might infect at their workplace:

> *"If you go to your workplace, you may infect healthy co-workers for whom COVID-19 is unproblematic and will not develop symptoms. However, you may also infect colleagues in a more vulnerable risk group for whom the Coronavirus is very dangerous and who may suffer greatly. For example, people with pre-existing chronic diseases, such as cardiovascular disease, diabetes, or a chronic respiratory disease.*".

Worst-case

Participants read a similar scenario to the control scenario in the worst-case scenario. However, additional information was added between the previous paragraphs stating that they would infect a co-worker for whom the infectious disease would be dangerous if they went to their workplace.

> "*If you go to your workplace, you can infect co-workers who are part of a more vulnerable group, for whom the Coronavirus is very dangerous, and they might suffer greatly. For example, people with pre-existing chronic diseases, such as cardiovascular disease, diabetes, or a chronic respiratory disease.*".

Indirect transmission

Participants read a similar scenario to the control scenario in the indirect transmission. However, additional information was added between the previous paragraphs suggesting that they could infect somebody for whom the disease would be unproblematic, even though this person could infect people who were part of a more vulnerable group.

> "*If you go to work, you may infect healthy co-workers for whom COVID-19 is unproblematic and will not develop symptoms. However, these colleagues may infect people who make part of a more vulnerable group, for whom the Coronavirus is very dangerous and who may suffer greatly. Such as people with pre-existing chronic diseases like cardiovascular disease, diabetes, or with a chronic respiratory disease.*".

After reading the scenario presented, participants made two possible judgments (that is, the possibility that co-workers are vulnerable and the possibility of infecting co-workers) by pressing a key to indicate whether they thought the event was possible or impossible. The two possibility judgments were presented in random order. Thus, participants were either forced to make these judgments very quickly (≤ 2 s) or asked to deliberate on the possibility of each event.

Finally, following their possibility judgment, participants proceeded to indicate whether or not they would go to work in the scenario they had read, on a seven-point Likert scale from '*definitely not*' to '*definitely*', also under time pressure (≤ 6 s) or without time limit.

4.3.4. Procedure

The online questionnaire was developed in Qualtrics software (Qualtrics, 2020). Participants were randomly assigned to one condition. More specifically, participants were divided into eight conditions in a 4 (COVID-19 scenario: Control vs. Impact Uncertainty vs. Worst-Case vs. Indirect Transmission) × 2 (decision time: time delay vs. time constraint) between-subject design. Participants started by responding to the first two questionnaires regarding sociodemographic variables and questions relative to COVID-19. Then, participants answered the main task and started by practicing how to respond to the possibility judgments. After the practice trial, participants read their scenario and receive instructions regarding their experimental condition– time delay or time pressure (similar to Rand et al., 2012). Participants were asked to make each decision as quickly as possible in the time pressure condition. They were told they could not take longer than 2 seconds (in the possibility judgments) and 6 seconds (in the prosocial behavior question of whether they would leave home to go to work). In this condition, a timer appears on the screen to show the time left to decide participants could not respond after the time had ended. On the other hand, in the time delay condition, participants were asked to consider their decision carefully; no timer appeared, and they could choose at any moment. Later, participants responded to the two possibility judgments and the prosocial behavior question of whether they would leave home to go to work in the scenario they had read. Participants ended the procedure by responding to the four questionnaires evaluating empathy, social value orientation, probabilistic discounting task, and the COVID-19 risk perception scale presented in random order. Participants took, on average, 15 min to complete the questionnaire.

4.4. Data Analysis

We first assess the effects of the uncertainty scenarios presented and time manipulation on participants' likelihood of leaving home by conducting an ordinal logistic regression (OLR) while controlling for the response phase. We expected to observe if the likelihood of leaving home would be higher for the deliberate (no time limit) vs. intuitive (time limit) condition and if this likelihood would change for the different scenarios compared to the control condition. Before analyzing the effects of the individual differences, we extracted the most relevant information from the COVID-19 Risk Perception Scale by

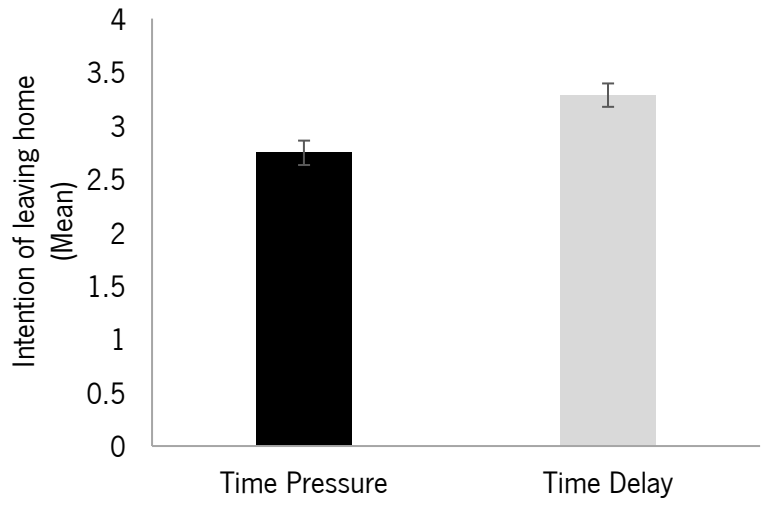
performing a principal component analysis (PCA) and a confirmatory factor analysis (CFA). Then, in order to explore whether individual differences could explain the likelihood of leaving home, a second OLR was conducted. More specifically, to analyze if specific variables were predictors of the prosocial decision made, namely: (i) probabilistic discounting task; (ii) the COVID-19 risk perception scale; (iii) question regarding how participants believe in the future people will follow the recommendations of the general health direction; iv) empathy (interpersonal reactivity index); and v) sociodemographic variables: age, gender, and socioeconomic status. Additionally, we conducted an Analysis of Variance (ANOVA) and Kruskal-Wallis test to explore individual differences across the conditions. Finally, we also performed a multiple linear regression model to understand the contribution of each of the items from the COVID-19 Risk Perception Scale towards the intention of leaving home. Data analysis was performed using R (R Core Team, 2021; RStudio (Version 1.4.1103; RStudioTeam, 2021).

4.5. Results

Before proceeding with a formal statistical model, we first investigated the data at its mean level. Figure 15 shows the mean decision of leaving home (participants indicated whether or not they would go to work in the scenario presented on a seven-point Likert scale from 1 '*definitely not*' to 7 '*definitely*) in each of the two conditions (time pressure vs. time delay). Regarding the dual-process manipulation, participants in the time pressure condition appeared more likely to stay at home (M = 2.74) than the participants without a time limit (M = 3.28).

Figure 15

The Intention of Leaving Home for the Two Types of Dual-Process Manipulation

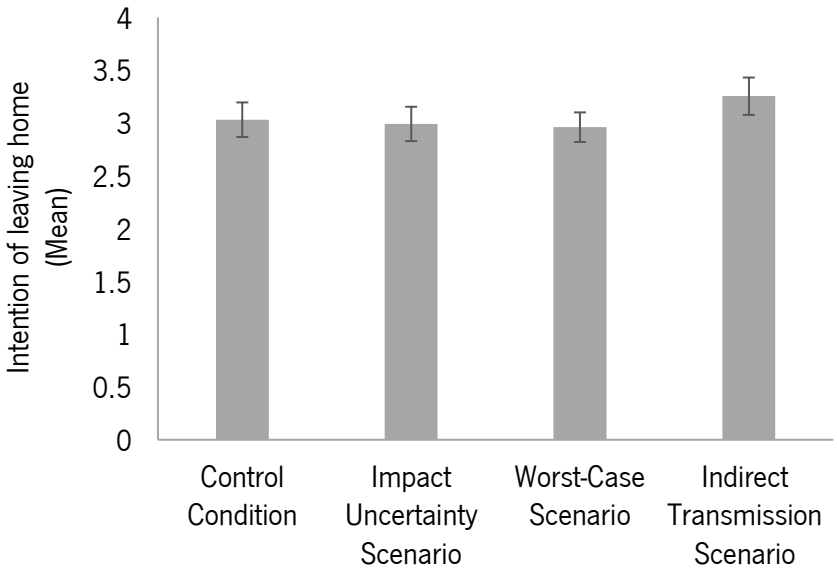


Note. Error bars represent the standard error of the mean.

Regarding the uncertainty manipulation conditions, mean data reveal that participants in the impact uncertainty and worst-case conditions have a lower mean decision to leave home when compared to the median decision of participants in the control condition. Conversely, participants in the indirect transmission scenario have a higher mean intention to leave home when compared to the mean data of the other three scenarios (see Figure 16). In order to confirm these results, an ordinal regression was performed.

Figure 16

The Intention of Leaving Home for the Four Scenarios Presented



Note. Error bars represent the standard error of the mean.

The first OLR was composed of both time pressure and scenario main effects entered as predictors and the intention to leave home to work as the dependent variable while controlling for the response phase (see Table 14). The model revealed that time pressure had a statistically negative effect on the likelihood of leaving home (β = -.50, *SE* = 0.16, *t*(494) = -3.09, *p* = .002, *OR* = 0.61, 95% CI [0.44, 0.83]). The odds ratio was 0.61, which means that for the time limit condition, the probability of leaving home was 0.60 lower than for the no time limit.

Relatively to the scenarios condition, no differences were found between the different scenarios in comparison to the control scenario condition: impact uncertainty (β = -.02, *SE* = 0.23, *t*(244) = -0.08, *p* = .94, *OR* = 0.98, 95% CI [0.63, 1.54]); worst-case (β = -.002, *SE* = 0.22, *t*(253) = -0.07, *p* = .99, *OR* = 1.54, 95% CI [0.65, 1.54]); nor for the indirect transmission (β = .19, *SE* = 0.23, *t*(247) = 0.84, *p* =

.40, *OR* = 1.21, 95% CI [0.77, 1.90]). Also, the response phase did not show a significant effect (β = .20, *SE* = 0.17, *t*(494) = 1.18, *p* = .24, *OR* = 1.22, 95% *CI* [0.88, 1.69]).

Table 14

Estimates of the Ordinal Logistic Regression Model

	β (*SE*)	*t value*	*p*	95 % *CI* for odds ratio		
				LL	Odds Ratio	*UL*
Intercept						
Time manipulation	-.50(.16)	-3.09	.002**	.44	.61	.83
Scenario: Impact Uncertainty	-.02(.23)	-.08	.938	.63	.98	1.54
Scenario: Worst-Case	-.00(.22)	-.01	.994	.65	1.00	1.54
Scenario: Indirect Transmission	.19(.23)	.84	.400	.77	1.21	1.90
Response Phase	.20(.17)	1.18	.238	.88	1.22	1.69
AIC	1771.19					
Number of obs.	496					

Note. β = coefficient; *SE*= standard error of the coefficient; *CI*- = confidence interval; *LL* = lower limit; *UL* = upper limit; AIC =The Akaike information criterion.

* *p* <.05. ** *p* <.01. *** *p* <.001.

4.5.1. Dimensionality Reduction From the COVID-19 Risk Perception Scale

An initial principal component analysis with varimax rotation indicated that three dimensions should be extracted from the COVID-19 Risk Perception Scale: perceived spread (3 items), perceived impact (4 items), and perceived distant spread (2 items). Thus, confirmatory factor analysis was performed, which showed a good fit (χ^2= 57.99, *df* = 24, *p* < .001; comparative fit index (CFI) = .94; Tucker–Lewis index (TLI) = .92; root mean square error of approximation (RMSEA) = .07. The relative figure and loadings from the confirmatory factor analysis are presented in Appendix C (Figure C.1 and Table C.2).

4.5.2. Ordinal Logistic Regression (OLR) for the Individual Differences

The second OLR was composed of the participant's response to the: probabilistic discounting task; the COVID-19 risk perception scale; the question regarding how participants believe in the future people will follow the recommendations of the general health direction; the interpersonal reactivity index; age; gender; and socioeconomic status.

The model was comprised of only 254 entries due to not all participants having completed the full questionnaire. Table 15 presents the results found in the ordinal logistic regression for the individual differences. We found a negative significant effect for the perceived COVID-19 impact (β = -.21, *SE* = 0.11, $t(252)$ = -2.03, p = .042, *OR* = 0.81, 95% CI [0.66, 0.99]), a negative effect of age (β = -.04, *SE* = 0.02, $t(252)$ = -2.13, p = .034, *OR* = 0.96, 95% CI [0.92, 1.00]), and a significant negative effect between subjects with higher socioeconomic levels compared to individuals with lower socioeconomic conditions (β = -.78, *SE* = 0.38, $t(87)$ = -2.02, p = .043, *OR* = 0.46, 95% CI [0.22, 0.98]), and an effect approaching the significance level for individuals with moderate socioeconomic levels (β = -.51, *SE* = 0.29, $t(214)$ = -1.76, p = .078, *OR* = 0.60, 95 % CI [0.34, 1.06]). The other individual variables present in the model were not significant predictors of the intention of leaving home (see Table 15).

Table 15

Estimates of the Ordinal Logistic Regression Model for the Individual Differences

	β (SE)	*t value*	*p*	95 % CI for odds ratio		
				LL	Odds Ratio	*UL*
Intercept						
Probabilistic Discounting Task: AUC	.90(.54)	1.67	.095	.85	2.47	7.11
COVID-19 Risk Perception: Perceived Spread	.17(.11)	1.66	.098	.97	1.91	1.46
COVID-19 Risk Perception: Perceived Distant spread	-.05(.15)	.33	.741	.79	1.05	1.40
COVID-19 Risk Perception: Perceived Impact	.-.21(.11)	-2.03	.042*	.66	.81	.99
IRI-Perspective Taking	.05(.03)	1.52	.130	.99	1.05	1.25
IRI-Empathic Concern	-.01(.05)	-.24	.810	.95	.99	1.00
IRI-Personal Distress	-.05(.03)	-1.83	.067	.89	.95	1.00
IRI-Fantasy	-.00(.03)	-.13	.900	.95	1.00	1.05
Gender	.41(.37)	1.10	.274	.72	1.50	3.13
Age	-.04(.02)	-1.83	.034*	.92	.96	1.00
SES: level 2	-.51(.29)	-1.76	.078	.34	.60	1.06
SES: level 3	.77(.38)	-2.02	.043*	.22	.46	1.00
Follow the recommendations of the general health direction	-.06(.10)	-.64	.516	.66	.81	.99
AIC	888.34					
Number of obs.	254					

Note. β = coefficient; *SE* = standard error of the coefficient; *CI*- = confidence Interval; *LL* = lower limit; *UL* = upper limit; AIC-=The Akaike information criterion.

* $p < .05$. ** $p < .01$. *** $p < .001$.

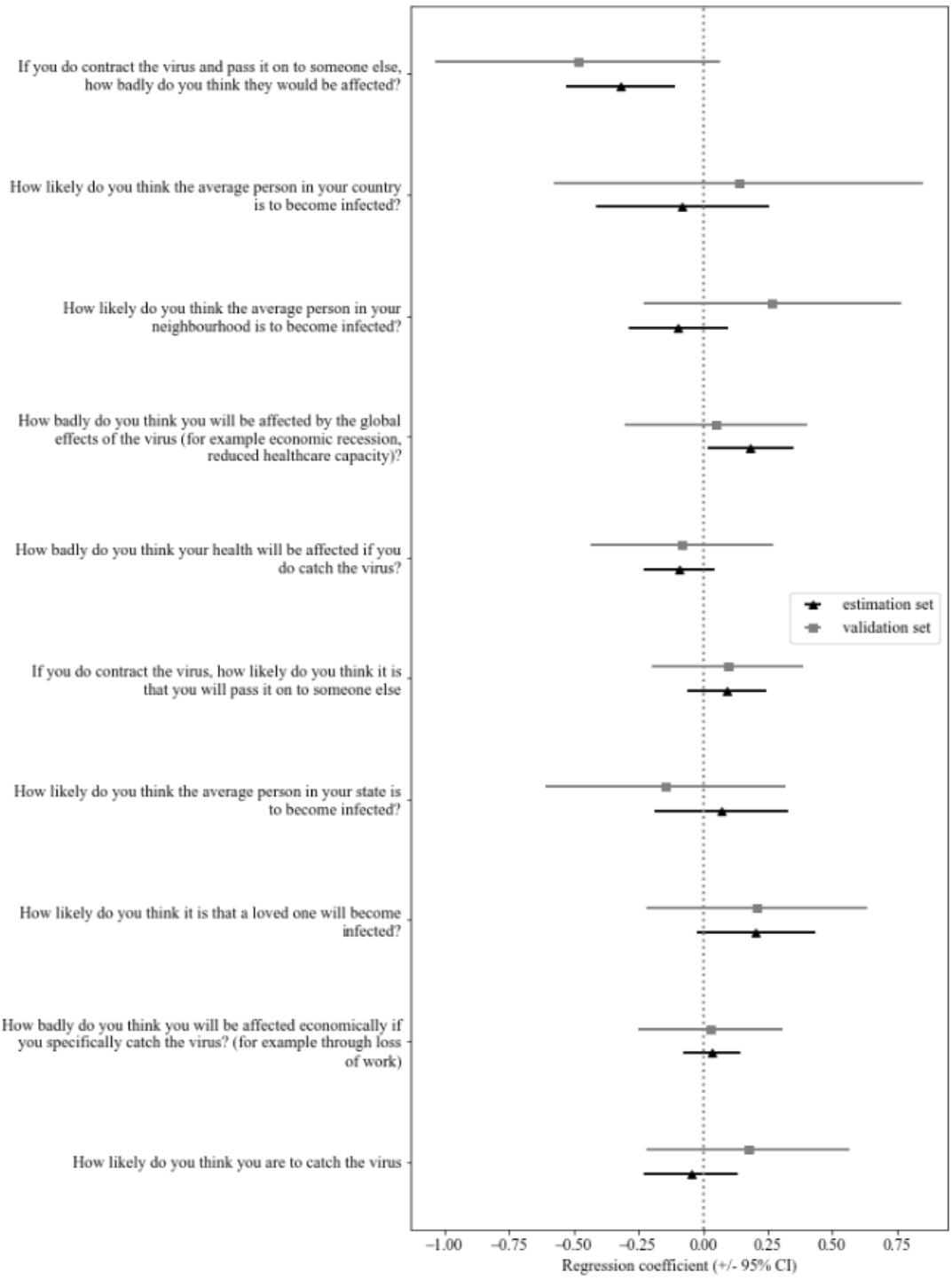
Additionally, we conducted ANOVA and Kruskal-Wallis tests and found no effect on individual differences across the different conditions, except for a significant effect in the socioeconomic status ($\chi 2 = 15.34$, $p = .03$; see in Appendix C- Table C.3). However, pairwise post-hoc Dunn test with Bonferroni adjustments did not reveal differences in the socioeconomic status across the conditions (see Appendix C – Table C.4.).

4.5.3. The Predictive Power of the COVID-19 Risk Perception Scale

To understand the contribution of each of the ten items from the COVID-19 risk perception scale toward the intention of leaving home, we performed a multiple linear regression model. To ensure the reproducibility of our results, we performed this analysis in a subset consisting of 80% of participants and repeated it in a validation set with the remaining 20%. The results reported here are from the complete database, although they are consistent with findings in both subsets. We want to highlight that the perceived negative effects for another individual that the participant infected decreased the intention of leaving home ($\beta = -.39$, $t(262) = -3.96$, $p < .001$). Surprisingly, none of the other items showed a significant effect (see Figure 17).

Figure 17

Results of Linear Regression Predicting the Intention of Leaving Home from Risk Perception Measures, With Validation in a Subsample of 20% of the Subjects.



4.6. Discussion

The main objective of the present study was to analyze the impact of intuition on individual prosocial intention under uncertainty caused by COVID-19. For that, we manipulated the uncertainty

conditions based on fictive scenarios set in the context of COVID-19. In the control condition, participants read about the situation caused by COVID-19, its spread, and how people they contact may get infected. Across the uncertainty conditions, we vary the information regarding the susceptibility of those they might infect. After reading the scenario presented, participants indicated whether or not they would leave home to go to work based on the scenario they had read, either under time pressure (intuition) or without a time limit (deliberation).

4.6.1. Effects of Intuition on Prosocial Behavior

Consistent with our first hypothesis, our results revealed that participants in a time pressure condition diminished their intentions of leaving home to go to work relative to participants without a time limit. These findings suggest that intuition favors prosocial intention. Additionally, our results supported previous research that observes that participants who made implicit possibility judgments (under time pressure) were less likely to reveal they would go to work - prosocial behavior - than those who made explicit possibility judgments (under a time delay; Kappes et al., 2018). Moreover, previous research has demonstrated that time pressure manipulation increases cooperative behavior in experimental economic games (Rand, 2016; Rand et al., 2012). These findings contribute to the study of the SHH by expanding the knowledge in this area to real-case scenarios and not only to economic games. Considering the SHH, people adopt generally advantageous and effective approaches in their social interactions when their capacity to deliberate is impaired (Rand, 2016; Rand et al., 2012). Research has shown that social norms influence how individuals lead their lives within a society (Bavel et al., 2020; Greene, 2013; Tomasello, 2009). These shared social norms are emphasized by social enforcement mechanisms that encourage individuals to adopt and internalize social norms and motivate individuals to act more correctly while avoiding behaving inappropriately (Bavel et al., 2020; Ellemers, 2017). In the COVID-19 uncertainty scenario presented, participants have internalized prosocial behavior, which means that individuals internalize the preventive measures of staying at home recommended by the local governments and health authorities.

Recent research suggested that it is essential to analyze which cognitive manipulations best promote the acceptance of preventive behaviors (Capraro & Barcelo, 2021). In their study, the authors use conceptual primes of emotion and reason to activate Type 1 and Type 2 cognitive functioning. Their study revealed that priming reasoning significantly increases intentions to wear a face-covering mask than priming people to depend on their emotions (Capraro & Barcelo, 2021). However, our results suggest that time pressure increases the prosocial decision to stay at home. Considering these two results, future

research using the same procedure should explore the cognitive basis of prosocial behavior during COVID-19 using different procedures like conceptual primes, ego-depletion, cognitive load, two-response paradigm, and neurostimulation (Capraro, 2019).

4.6.2. Effects of Uncertainty on Prosocial Behavior

Our data did not confirm our second and third hypotheses regarding the uncertainty's effect on cooperation. In our second hypothesis, we expected prosocial intention to be higher under impact uncertainty and in the worst-case scenario than the control condition. Moreover, in the third hypothesis, we expected lower prosocial intention under an indirect impact scenario than in the control condition. Contrary to our expectations, our results reveal no difference across the different scenarios read in the decision to leave home. As in previous studies, we found out that uncertainty does not always reduces prosocial behavior (Kappes et al., 2018). However, we did not find the same pattern. Our results showed that the type of uncertainty did not have an effect on the prosocial intention when participants answered to an actual infectious disease case.

Making moral decisions frequently involves uncertainty during a global pandemic once it is uncertain whether one is infected and will infect others (Bavel et al., 2020). Individuals may be less inclined to cooperate with others when gains are uncertain (Bavel et al., 2020; Garcia et al., 2020; Kappes et al., 2018). However, previous research has suggested that focusing on worst-case scenarios may have encouraged people to sacrifice for others even if the advantages were uncertain (Bavel et al., 2020; Kappes et al., 2018). In addition, when individuals have to make moral decisions, they often reflect on how others would evaluate them for acting in a self-centered manner (Bavel et al., 2020). Our results suggest that moral decisions are of great importance in a pandemic crisis, implying that participants want to maintain a good reputation by staying home and complying with health authorities' orientations. Since disrespecting the preventive measures and social norms during the pandemic will be severely judged (Bavel et al., 2020).

We can also consider that we did not find an effect since our baseline condition was too close to the uncertainty we are currently living. In the control condition, participants were asked to consider the possibility of being infected and asymptomatic or not infected. Since this condition presents uncertainty, it may not be the best control condition, and future research should compare the uncertainty conditions with no exposure. Possibly, the awareness of infection rates and the likelihood of severe symptoms caused by COVID-19 reduces all conditions to the impact uncertainty condition.

4.6.3. Effects of Individual Differences on Prosocial Behavior

Considering previous research on how individual differences may influence cooperative and prosocial behavior (Petrocchi et al., 2021; Pfattheicher et al., 2020; Thielmann et al., 2020; Wei et al., 2016), we explored how individual differences (probabilistic discounting, COVID-19 risk perception, empathy, age, gender, SES) predicts prosocial behavior during the COVID-19 pandemic. Results revealed that older individuals report a lower intention to leave home. This result is consistent with the literature since older adults have a higher risk of suffering from COVID-19, so the perceived risk for these individuals is higher than that for young adults (Leder et al., 2020; World Health Organization, 2021). Additionally, we found that socioeconomic status is a predictor of prosocial behavior. The results indicate that participants who report a medium-high socioeconomic status have less intention of leaving home than participants who report having a medium-low socioeconomic status. Previous research reveals that socioeconomic characteristics did not affect cooperative behavior (Gächter et al., 2004). Nevertheless, socioeconomic variables affect trust attitudes, which are associated with an individual's cooperative behavior (Gächter et al., 2004). In particular, people's socioeconomic status significantly impacts their trust in the fairness of others and their fear of being exploited by others. In other words, those who believe that others will not exploit them cooperate more than those who believe the opposite (Gächter et al., 2004).

We also found that the perceived COVID-19 impact significantly predicts the intention to leave home. When participants perceived a higher rate of negative impact from the global, economic, and health consequences of COVID-19, they were more likely to leave home. Thus, special attention should be given to communicating and nudging more vulnerable groups (e.g., people with poorer socioeconomic status and older adults) to adopt preventive measures since these groups generally suffered more during the pandemic. Our results revealed that participants' intention of leaving home decreases if they could infect someone, and the person would suffer badly. This effect is consistent with previous findings since focusing on how badly others could suffer from the disease will increase prosocial behavior (Kappes et al., 2018).

The other individual differences did not reveal a significant effect in predicting the intention of leaving home. In our analysis, we decided not to apply the social value orientation since our sample was too homogeneous. More specifically, most of our participants were prosocially oriented individuals. However, a recent study found no evidence that SVO influenced either the perception or the frequency of protective measures (Leder et al., 2020). Like our sample, most participants in their study were categorized as prosocial (Leder et al., 2020).

Regarding the limitations of our study, the first is that our sample was relatively young, with a median age (26.11 years), and mainly consisted of women (75.4%). Our sample was at low risk of serious illness due to the pandemic, primarily female and young (Leder et al., 2020; World Health Organization, 2021). Therefore, the observed optimism bias could be based on being genuinely lower risk than the average person. Another limitation in our study that could influence participants' decision to stay home is that most of our sample were university students for whom the possibility of working from home was not problematic. So, our scenario manipulation could not have the impact we would imagine.

4.6.4. Conclusion

Several studies have analyzed different strategies for engaging in effective science communication, persuasion over public health, and nudging people to adopt preventive measures (Bavel et al., 2020; Capraro & Barcelo, 2020, 2021; Jordan et al., 2021). These studies have focused on preventive measures like face-covering masks and social distancing (Capraro & Barcelo, 2020, 2021). On the other hand, our study focuses on whether participants decide to leave home to go to work or not since the lockdown measure is one of the most restrictive preventive measures the local governments have applied.

With this study, we contribute to the literature by revealing that participants were more inclined to behave more prosocially when forced to make their decision quickly rather than when given time to reflect on actual infectious diseases. Our results showed that time pressure manipulation significantly impacts prevention intention even after preventive behaviors have become a widespread social concern. Additionally, our findings revealed that uncertainty does not matter when presented with an actual infectious disease, and participants adopt preventive behaviors anyway. Even though most countries have softened the restrictive measures as the vaccination proceeds, the fight against COVID-19 is still uncertain since it will depend on the duration of vaccine protection, the emergence or not of new variants, and people's behavior. Therefore, messages that focus on the uncertainty of people contracting and spreading the disease, urgency appeals, and intuition priming can help to keep the public on its guard against the disease and promote preventive behaviors within the population.

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CHAPTER 5

General Discussion

The main objective of the present doctoral thesis was to provide a more comprehensive perspective on the effects of the cognitive basis of cooperation under uncertain situations by manipulating time pressure. Accordingly, this dissertation comprised four experimental studies in which we manipulated time limits in a one-shot and repeated Prisoner's Dilemma (PD) game with and without stochastic payoffs (Chapters 2 and 3) and in a hypothetical decision concerning the threat of Coronavirus Disease 2019 (COVID-19; Chapter 4). Our results suggested that manipulating time pressure enhances cooperative decision-making behavior, even in a social dilemma with a relatively uncertain context. Thus, the results advance our understanding of the cognitive basis of cooperation in games where participants are uncertain regarding the outcome. Furthermore, our results showed that participants tend to be more cooperative and take fewer risks under time-pressure conditions, providing further support to the Social Heuristic Hypothesis (SHH).

In this final chapter, we aim to discuss the findings of the studies developed in the previous chapters into a broader perspective. To accomplish this, we will start by summarizing the most important findings. Then, we will provide an overview of the strengths and limitations of our studies, make suggestions for future research, and discuss the general implications.

5.1. Summary of the Main Findings

The first study (i.e., Study 1) contributes to the literature by examining behavior in repeated prisoner's dilemmas in a losses frame when there is a stochastic and deterministic payoff and a time pressure manipulation. Our main goals were to understand whether and when participants cooperate or defect in the different payoff matrix with probabilistic or deterministic results while analyzing the influence of cognitive processing manipulations and learning effects. We presented evidence from four different conditions: participants either played a Stochastic Prisoner's Dilemma (SPD) or a Deterministic Prisoner's Dilemma (DPD) in a time-pressure or time-delay condition. In this study, participants' cognitive processes were manipulated by varying the information considering the time available to select their response. Participants in a time pressure condition were instructed to be as fast as possible and to decide in less than 10 seconds. In this condition, the time left to decide appeared on the decision screen. In the time delay condition, participants read the instruction that they should think carefully before making a decision and could respond at any time. Results from our first study demonstrated a learning process whereby participants learned not to cooperate over time. Furthermore, results revealed that participants cooperate more in the first 50 rounds of the game under a time pressure than under a time delay condition. However, this positive effect was not maintained throughout the entire duration of the game task.

The results found appear consistent with previous research that revealed that participants were affected by the previous actions of their interaction partners in repeated games (Fudenberg et al., 2012; Nishi et al., 2016; Santa et al., 2018). Furthermore, previous studies have shown that reciprocal decisions are made more quickly, suggesting that the social environment influences the speed of cooperative decisions (Nishi et al., 2016). Our findings seem to suggest that time pressure enhanced individuals' cooperation rates in the first 50 interactions, where the environment could be more cooperative. For example, individuals tend to cooperate more at the beginning of every new interaction, especially in a time-pressure condition. Our results also demonstrated an end-game effect: participants tend to a Subgame Perfect Nash Equilibrium to mutual defection (similar to Duffy & Smith, 2014). Additionally, participants in the final interactions in both games made extremely fast decisions, and previous research has suggested that under extreme time pressure, participants have lower cooperation rates (Capraro & Cococcioni, 2016). The authors have proposed the existence of an inverted-U relationship between cognitive effort and cooperation, such that cooperation is only favored under light time pressure effects (Capraro & Cococcioni, 2016).

Following the results of our first study, we designed a second study (i.e., Study 2) to address certain limitations of the previous research and further examine the SHH's effects. This study aimed to investigate the influence of cognitive processing on cooperation under different contextual factors involving gains and losses frames, as well as risk and uncertainty. Therefore, we conducted two experiments: a one-shot and a repeated PD. In both experiments, we manipulated the available time for making a decision (time pressure vs. forced time delay), the game type (stochastic vs. deterministic), and the frame type (gains vs. losses).

In the two experiments reported in Study 2, we addressed some limitations from the previous study (Study 1). Specifically, (1) we introduced a forced time delay condition; (2) we introduced a gain frame; and (3) we implemented a comprehension task to ensure that all participants understood the game payoff structure before starting the experiment. We considered that these modifications would lead to higher cooperation rates over time. Considering previous research, participants seem to cooperate more under a gain frame than under losses (Everett et al., 2017; Isler et al., 2021). According to Strømland and colleagues' (2018) working paper, understanding the payoff structure can help resolve the inconsistent findings in the literature regarding the relationship between time pressure and cooperation in a one-shot Public Goods Game (PGG). Results from their study and a re-analysis of previous experiments suggested that individuals who understand the payoff structure demonstrated a positive effect of time pressure on cooperation (Strømland et al., 2018). Additionally, Isler et al. (2018) supported

these findings by revealing a positive effect of time pressure on cooperation for individuals who understand the social dilemma. As previous research has indicated, adjusting the game's payoff structure to favor more cooperative decisions would enhance the speed in which individuals make more cooperative decisions while enhancing the appeal of defection would lead to a higher speed of non-cooperative choices (Evans & Rand, 2019; Nishi et al., 2016). With the implementation of these differences from Study 1 to Study 2, we observed a positive effect of time pressure on cooperation throughout the entire duration of the game. These findings might highlight the importance of payoff comprehension described by Strømland and colleagues (2018) in predicting the time-pressure effect in social dilemmas. Future research should better identify the effect of these comprehension tasks in the game, especially in stochastic games, which participants might not fully understand due to their complexity and the fact that the outcomes are probabilistic.

Our results from the first experiment supported the SHH (Rand, 2016), revealing that time pressure manipulation promoted cooperation in a one-shot DPD. We extended previous research (Capraro, 2023; Rand, 2016) by showing that time pressure manipulation also favors cooperation in a one-shot game involving stochastic outcomes. The new evidence presented in this study indicates that manipulating time pressure promoted cooperation in a condition with environmental and social uncertainty, which, according to prior research (van Dijk et al., 2004), may have a negative impact on cooperation. This finding that promoting intuition still leads to higher levels of cooperation in such conditions suggested that intuition led to a more general tendency to cooperate (Cone & Rand, 2014; Everett et al., 2017; Rand et al., 2015). We also revealed that time pressure manipulation enhances cooperation even in a loss frame context, similar to Everett et al. (2017).

In the second experiment of Study 2, we analyzed a repeated version of a stochastic and deterministic PD game, as in Study 1. Results from the second experiment indicated that cooperation under time pressure was much higher in the initial round of each supergame than in the subsequent rounds. These findings support previous studies by Gallotti and Grujić (2019) as well as the observations from Study 1.

Our results from the repeated games suggested that participants cooperated more in an SPD than in a deterministic game. This effect contradicted previous research using the same type of game (Gong et al., 2009; Kunreuther et al., 2009). The discrepancy in results may be attributed to the manipulation of the decision time available since, in previous studies, the authors did not inform participants regarding the time available to make a decision (Gong et al., 2009; Kunreuther et al., 2009). Results from the interaction effects of Study 2 revealed that participants under a time pressure condition

cooperated more in both types of games (in an SPD and a DPD game) than in a forced time delay. In addition, results demonstrate that participants cooperated more under time pressure conditions in an SPD game than in a DPD. These findings seem consistent with recent literature (van den Berg et al., 2021), which indicated that individuals are more likely to rely on social heuristics and cooperate when faced with uncertainty. Alternatively, participants in the stochastic game may have cooperated more under time pressure to avoid conflict (Jarke-Neuert & Lohse, 2022) since mutual cooperation in the stochastic game did not yield a probabilistic outcome for all players, thus reflecting a risk-averse strategy. In sum, results from both experiments presented in Study 2 suggested that time pressure encourages greater cooperation and reduced risk-taking compared to time delay.

In the repeated games (Study 1 and the second experiment of Study 2), our findings demonstrated a learning process, meaning that participants learned over time to cooperate more in the early rounds and less in the later rounds of the supergame. Additionally, participants from Study 2 exhibited a slower learning rate from one supergame to the next in the SPD. This slower negative trend in the stochastic condition supported the hypothesis that partial reinforcement slows down the learning process (Bereby-Meyer & Roth, 2006). We also found evidence that participants exhibited more strategic defection near the supergame end and tended to the Subgame Perfect Nash Equilibrium. In addition, we found that participants relied more on their past decisions when they had more time for reasoning. These results are similar to the ones found by Duffy and Smith (2014).

Study 3 aimed to investigate the impact of intuition on individuals' willingness to engage in prosocial behavior during uncertain situations caused by COVID-19. To achieve this, we manipulated the levels of uncertainty using a fictitious scenario involving this disease. In the control condition, participants obtained information about the contagious nature of COVID-19. The uncertainty conditions were adjusted by modifying the information participants received regarding the susceptibility of the individuals they might infect. After reading the scenario, participants indicated how likely they were to leave their homes to go to work either under a time constraint or without a time limit. Results from Study 3 revealed that participants in the time constraint manipulation were more likely to remain at home than those without a time limit. This result supports the findings of Kappes et al. (2018) study 6, in which participants who made implicit possibility judgments were less likely to go to work than those who made explicit ones. In addition, the findings found in this study are consistent with previous research that revealed that time pressure manipulation improves cooperation in experimental economic games (Rand, 2016; Rand et al., 2012). Our findings might provide support to the SHH research by developing the knowledge in this area to real case scenarios and not just economic games. In the COVID-19 uncertainty scenario, participants

had internalized prosocial behavior, meaning that individuals incorporated the safety precautions of staying at home endorsed by the local governments and the General Health Direction and tended to cooperate by default.

Our Study 3 also investigated the effect of uncertainty on prosocial behavior. Previous research has suggested that this type of behavior decreases under outcome uncertainty (Kappes et al., 2018; van Dijk et al., 2004). Nonetheless, recent research suggested that uncertainty is not always detrimental, and prosocial behavior is improved under impact uncertainty (Kappes et al., 2018). Our study showed no significant differences regarding prosocial behavior across different levels of uncertainty. Participants were motivated to comply with local government regulations and maintain a good reputation by staying at home. In summary, our study found that time pressure manipulation encourages prosocial behavior and that individuals were motivated to comply with local regulations during uncertain situations caused by COVID-19.

Recently, researchers studying cooperation and human prosociality have argued that the impact of intuition on prosociality or self-interest may depend on several individual, social, and contextual factors (Capraro, 2023; Fromell et al., 2020; Isler et al., 2021). The results presented in this doctoral thesis also suggest that intuition enhances prosociality but in a specific context where it is easier to observe if the SHH is valid, as these studies were conducted in a relatively cooperative and trusting environment among university students (Rand et al., 2014). Additionally, the majority of our study population tends to be prosocial. For example, the study conducted by Alós-Ferrer and Garagnani (2020) yielded different results from ours, as they did not find a general effect of time pressure manipulation. Instead, they found that time pressure interacted with Social Value Orientation (SVO), amplifying prosocial behavior among prosocial individuals, leaving individualists unaffected, and intensifying competitive behavior among competitors and highly individualistic individuals. However, it is worth noting that the sample used by Alós-Ferrer and Garagnani (2020) differed in the number of prosocial and proselfs individuals compared to our studies. They included 109 proself and 51 prosocial participants, while our studies mainly consisted of prosocial individuals. Specifically, in Study 2, the first experiment included 131 prosocial and 61 proselfs participants, and the second experiment had 112 prosocial and 80 proselfs participants. In addition, in Study 3, the majority of the population was prosocial. Therefore, considering these differences in prosociality across studies, the lack of results regarding the general effect of time pressure manipulation in Alós-Ferrer and Garagnani (2020) study could be attributed to the fact that most of their population consisted of proself individuals. In addition, similar to the findings of Alós-Ferrer and Garagnani (2020),

results from our second study involving a repeated PD game suggested that time pressure manipulation interacts with individual characteristics.

Based on the studies reported in this dissertation, it can be argued that participants made more cooperative behaviors when asked to make a quick decision, even in contexts where there is relative uncertainty regarding the outcome of the game and the uncertainty of infecting others with COVID-19. Even though the effect of time pressure manipulation may be context restricted to a more prosocial population, our four experiments have demonstrated that it can increase cooperation in situations where cooperative behavior is typically difficult to find, such as under conditions of uncertainty and loss frames.

5.2. The Relationship Between Uncertainty and Time Constraints on Cooperation

Our second experiment in Study 2 revealed a significant interaction effect between the type of game (with or without probabilistic outcomes) and time manipulation. Our findings suggested that participants cooperate more under time pressure than under a forced time delay in both a stochastic and a deterministic game. The interaction effects also showed that participants cooperate more in SPD (when consequences were probabilistic) than in DPD games (when consequences were all known) under both time pressure and forced time delay. Additionally, in the first experiment of Study 2, the post hoc test revealed a significant difference: participants cooperate more under time pressure than under a forced time delay in the SPD. Considering this, our results showed that individuals under time pressure and uncertainty tend to cooperate more. Although Study 1 did not reveal a significant interaction effect, results also appear to indicate a positive pattern; namely, time pressure increases cooperation even in contexts of stochastic payoffs. Our preliminary results, supported by a limited number of participants, emphasize the need for further research in this area.

In our experiments involving stochastic games, the decision to invest if the other player also chose to invest resulted in certain outcomes for participants, unlike the other strategies where outcomes were probabilistic. In this case, participants seem to take fewer risks. One possible explanation for our results comes from the recent study by Jarke-Neuert and Lohse (2022) that suggested that time pressure leads to information avoidance, allowing decision-makers to make quick decisions without resolving conflicts (Jarke-Neuert & Lohse, 2022). In the first experiment of Jarke-Neuert and Lohse (2022), participants played a binary Dictator Game (DG) where payoffs from the recipient were initially hidden, and they could choose to reveal them. Results demonstrated that time pressure increased the incidence of information avoidance and self-interested choices. The second experiment added control conditions where recipients' and participants' payoffs were fully known, but results in this condition did not reveal any effect of time

pressure. In the final experiment, the authors hid the payoffs of the participants (i.e., dictator) and only revealed the payoff of the recipient. The study highlights that time pressure leads to information avoidance by allowing quick decisions without resolving potential conflicts (Jarke-Neuert & Lohse, 2022). Furthermore, their study found that time pressure did not affect prosocial behavior when consequences were known but had a significant effect when they were hidden (Jarke-Neuert & Lohse, 2022).

Contrary to the results from Jarke-Neuert and Lohse (2022), we found a significant main effect of time pressure when including both deterministic and probabilistic games. Previous research has also shown that decision-makers under time pressure tend to switch to simpler strategies (Ordóñez et al., 2015). This avoidance of conflicts may present one explanation that future research should consider when investigating the effects of time pressure on uncertainty, as individuals facing environmental uncertainty may cooperate more under time pressure to avoid conflicts. In the stochastic games we used, mutual cooperation avoided probabilistic outcomes.

In a recent study, Teoh and Hutcherson (2022) revealed that in cooperative contexts, such as the ultimatum game, time pressure increases the extent to which participants prioritize gathering information about others' outcomes. In the ultimatum games, the participant's outcomes depend on the other participant's satisfaction with the payoff division. Additionally, time pressure compelled individuals to make more frequent decisions without acquiring all relevant information, exacerbating the influence of these information priorities on prosocial behavior (Teoh & Hutcherson, 2022). This study suggested an overall prosociality enhancement under time pressure conditions only in situations where individuals prioritize looking for the other player's payoff over their own (Teoh & Hutcherson, 2022). In future research, it will be necessary to further develop these ideas by conducting a study similar to the ones reported in this dissertation, focusing on the type of information participants pay more attention to during the feedback stage. Following the findings from Teoh and Hutcherson (2022), we can assume that in our games, which also occur in a cooperative context, participants prioritized paying attention to the others' outcomes and maintaining equality between themselves and the other participants. Since maintaining equal outcomes in stochastic games is more challenging, participants often tend to mutual cooperation when there is no probabilistic outcome, and both players stand to gain or lose the same amount.

A recent study conducted by van den Berg et al. (2021) found that when people are uncertain about the outcome of helping others in a game, they tend to use a simple decision-making rule. The study varied the level of uncertainty participants experienced regarding the consequences of helping and found that participants were more likely to help others when there was more uncertainty. This occurred because they used a mental shortcut (i.e., heuristic) in uncertain conditions where they assumed that the middle

number of the possible outcomes was the real consequence of helping (van den Berg et al., 2021). When people do not know which outcome will occur, they tend to select the outcome that seems typical or likely (van den Berg et al., 2021). Because participants who had to deal with uncertainty used a heuristic, they ended up having more prosocial behavior than their counterparts. In our experiments, participants were more inclined to cooperate in the SPD under a time pressure condition. When participants had limited time for decision-making, they chose more often to cooperate and rely on situations that seemed typical and were advantageous in the past (Rand et al., 2014). Conversely, in the repeated game from Study 2, results suggest that participants relied more on their past decisions when they had more time to think. These findings may explain and demonstrate that uncertainty did not always have a detrimental effect on cooperation.

5.3. Limitations and Suggestions for Future Research

In order to gain a better understanding of the limitations and potential areas for future research of the studies developed in this doctoral thesis, we will discuss them by reflecting on some aspects of the work developed. We will provide a comprehensive overview of the factors that may have affected our findings' generalizations and identify areas for further research improvement.

5.3.1. Type of Game and Uncertainty Manipulation

In a laboratory setting (Studies 1 and 2), we investigated individual cooperation rates using Interdepend Security (IDS) games. Previous studies have used these games to examine the behavior of groups and group representatives compared to individuals regarding cooperation under uncertainty and risk (Atanasov & Kunreuther, 2016; Gong et al., 2009). Studying cooperative decisions made by groups and their representatives is essential, as many of our decisions are made within a group context or when representing a group. For example, studying the cooperative decisions of a team manager, since they usually make decisions for a group and their decisions have an impact on a group of individuals. Alternatively, being a member of a group of coworkers that are developing a common project, and within the group, decide whether to cooperate or not with others. Previous research has demonstrated that groups and group representatives cooperate less than individuals in the deterministic version of the game (Atanasov & Kunreuther, 2016; Gong et al., 2009). However, the pattern reverses in stochastic games, and groups and group representatives cooperate more than individuals acting alone (Atanasov & Kunreuther, 2016; Gong et al., 2009). Based on this pattern of results, we argue that it is crucial to further advance the studies of this dissertation by comparing the behavior of groups and group

representatives with that of individuals on different manipulations of time constraints and uncertainty. Therefore, instead of solely focusing on the individual level, comparing the responses of groups and group representatives would be pertinent. Further investigation into this topic is needed since it also seems possible that the behavior under time pressure in a stochastic game is similar to that of groups in the stochastic game of Gong et al.(2009) study.

In the SPD, participants knew that choosing to cooperate without the other player's subsequent cooperation resulted in a specific probabilistic payoff. Additionally, there would be no probabilistic result if both decided to cooperate. Therefore, deciding to "*invest*" could be considered risk-averse in this game because it reduces expected payoff variance (Atanasov & Kunreuther, 2016). Nevertheless, deciding "*not to invest*" is the option that minimizes losses (Atanasov & Kunreuther, 2016) and maximizes gains (in a gain-frame scenario). Consequently, future research should investigate if participants perceived the mutual cooperation option as the most risk-aversive option, similar to Atanasov and Kunreuther (2016), since this could present an alternative hypothesis to our results. Furthermore, subsequent studies should compare the results of the games we used with a stochastic game where all strategic payoffs are probabilistic (as in Bereby-Meyer and Roth, 2006) or implement a game with ambiguity (unknown probabilistic results) instead of using risky games.

Another consideration is the length of the repeated games developed in our study. In repeated game experiments, participants knew the extension of each supergame. However, they did not know the entire game duration (i.e., how many supergames they will play), similar to the games developed by Bereby-Meyer and Roth (2006) and Gong et al. (2009). Hence, to increase social uncertainty and avoid end-game effects in each supergame (i.e., participants learning not to cooperate in the final rounds), future research should introduce a condition in which there is uncertainty regarding the length of each supergame. Another suggestion for future research is to use a different presentation of the outcomes and probabilities in the SPD game, as risky choices in real-life situations often involve experiencing outcomes and probabilities. For example, following the study of Artinger et al. (2012), we could include environmental risk and decisions based on the experience since it would make studies in a laboratory setting more ecological. Moreover, since framing the PD as an economic or noneconomic game could impact the cooperative decision (Camerer, 2003; Pillutla & Chen, 1999), it would be interesting if future studies applied this game in a different context (such as a social task). Previous research has demonstrated that individuals contributed less when they viewed the situation as economic (an investment task) than in a noneconomic setting (a social task; Pillutla & Chen, 1999).

Regarding the study of social and environmental uncertainty manipulation, previous research has used different types of games and methods to investigate uncertainty effects on cooperation (van Dijk et al., 2004). We argue that it is essential for future research to conduct an up-to-date systematic review to address the influence of several types of uncertainty on social dilemmas that study cooperation.

5.3.2. Prize

One limitation of our first two studies (i.e., Study 1 and 2) concerns the final prize, as we used a random decision selection method (as in Gong et al., 2009). In the case of repeated games, participants made choices, and only the outcome of one random supergame would affect the final prize. This means that most supergames would not affect the final prize, and consequently, participants may not perceive their responses as being critical. Additionally, in our games, only two participants from the total sample that took part in each experiment would receive a prize. We consider that future research should attribute the gift card prize to a random player of the groups of four to increase competition within the game. By implementing this approach, participants would perceive their responses as more significant.

5.3.3. Time Limits Manipulation

We used time pressure manipulations to investigate the cognitive basis throughout the studies of this dissertation. Although we found a significant effect of time pressure manipulation on cooperation, it is important to acknowledge the potential limitations and address methodological considerations that future research should consider. As highlighted in previous research, one methodological limitation in our studies (Everett et al., 2017; Isler & Yilmaz, 2022; Isler et al., 2020) was the absence of control conditions. Without these control conditions, it is difficult to determine whether the findings found in experiments resulted from the activation of intuitive or reflective processes (Isler & Yilmaz, 2022; Isler et al., 2020). Therefore, future studies should incorporate control conditions when studying cognitive manipulations of intuitive and reflective processes. For instance, only a limited number of studies have used controls to differentiate the effect of time delay. (e.g., Everett et al., 2017). The results of the study conducted by Everett et al. (2017) supported the SHH, demonstrating that participants under a time pressure condition were more likely to cooperate. Additionally, it is essential to include a control condition to investigate if the opposite and null effects we found regarding the stochastic and deterministic game can be attributed to the manipulation of time. This will allow for a comparison with previous studies with a similar game parading (Gong et al., 2009 & Kunreuther et al., 2009).

Despite being extensively used in the literature, using time constraints raises several methodological issues, such as non-compliance with time limits (Bouwmeester et al., 2017; Tinghög et al., 2013) and the arbitrary duration of time limits used (Isler & Yilmaz 2022, Isler et al., 2020). Regarding non-compliance with time limits, a different method could have enforced the time limit by shutting down the decision screen when the time limit has been concluded (Jarke-Neuert & Lohse, 2022). However, this method is vulnerable to selection effects (i.e., a selection bias to a specific subgroup of the total sample; Kocher et al., 2019). In this case, participants' responses would have been excluded from the experiment without their decision being recorded, as the time limit had been reached (Jarke-Neuert & Lohse, 2022). In Studies 1 and 2, we included all participants in the analysis to avoid such biases. However, in Study 3, we had less experimental control since participants could leave the page and return to finish the online survey. To address this issue, we restricted the time pressure condition to participants who clicked the first button on the page within 6 seconds or less. A possible solution could be to implement monetary incentives for participants who respect the time limits (e.g., Alós-Ferrer & Garagnani, 2020; Jarke-Neuert & Lohse, 2022)

Recently, research has begun to systematically investigate the effectiveness of the different manipulations of deliberation and intuition since, until recently, this effect was largely unknown (Isler & Yilmaz, 2022; Isler et al., 2020). Isler and Yilmaz (2022) conducted an online study comparing the effectiveness of different experimental techniques to activate reflection and intuition in cognitive tasks. The authors found that long debiasing training[5] was the most efficient method to improve deliberation ratings, while emotion induction was the most efficient method for improving intuition ratings. Short debiasing training, decision justification, and monetary incentives were also shown to improve deliberation scores. These findings were similar to those found by Isler et al. (2020), which only analyzed the effectiveness of deliberation techniques. Additionally, results found that high and very high cognitive load and time pressure conditions of 5 s and 10 s time were effective in activating intuition (Isler & Yilmaz, 2022). On the contrary, recall, time delay, and reason induction manipulations were revealed as ineffective techniques to activate deliberation processes (Isler & Yilmaz, 2022). In our studies, we manipulated intuition and reflection using time limits; however, as suggested, we should be careful in considering the effects of the time delay as it might not be an effective manipulation of reflection (Isler & Yilmaz, 2022). In the study conducted by Isler and Yilmaz (2022), the time delay manipulations did not

[5] Debiasing training is a method used to make more reflective decisions (Isler et al., 2020). It increases the awareness of cognitive biases and provides strategies to reduce their influence (Isler & Yilmaz; 2022; Isler et al., 2020). Regarding the manipulation of debiasing training in Isler and Yilmaz (2022) study, the authors introduced two manipulations. In the short debiasing training participants learned the answers to three bias questions, and in a long debiasing training participants learned explanations to and wrote about three bias questions.

trigger more deliberation compared to the control conditions across the 10 s and 20 s delay conditions. These results were comparable to the results reported by Isler et al. (2020), which suggested that the lack of effects was due to the brief time delay durations investigated, and the authors referred to the need for future studies to explore the effectiveness of longer delay durations (Isler & Yilmaz, 2022). Furthermore, it would be valuable for future research to compare the effectiveness of several techniques for activating intuition and reflection in a laboratory setting and compare if the results are the same as the ones found in online studies (as the ones conducted in Isler and Yilmaz, 2022 and Isler et al., 2020).

One reason for the inconsistent results in the literature regarding the study of cognitive process in cooperation might be because previous studies have primarily used time pressure and delay to manipulate cognitive processing (Capraro, 2023; Isler & Yilmaz, 2022). As suggested, it will be essential to investigate the cognitive processes involved in cooperation under uncertainty using alternative intuition and reflection manipulations, such as cognitive load or others that have effectively demonstrated to manipulate intuition and reflection (Capraro, 2023; Isler & Yilmaz, 2022). In order to enhance the understanding of our results and advance the field, future research should use a more effective reflection manipulation, given the lack of effectiveness of time delay techniques.

One manipulation that research has found promising for effectively manipulating intuition and reflection is the application of the two-response paradigm (Isler & Yilmaz, 2022). Applying this paradigm to the studies will be essential to further develop dual-process theories and test the corrective dual-process model on prosocial behavior. A recent study by Bago et al. (2021) used a two-response paradigm and observed that most prosocial and selfish actions are made under intuition rather than the result of a deliberate correction. Even though corrective patterns were observed, they were rare (Bago et al., 2021). The authors concluded that prosocial and selfish decisions did not rely on distinct types of reasoning systems (e.g., intuitive Type 1 and deliberate Type 2) but on distinct types of intuitions (Bago et al., 2021). Additionally, future studies should apply a two-response paradigm to understand the cognitive basis of cooperation under situations of uncertainty.

Another pertinent variable to consider is the placement of time constraints in the instructions screen, a concern raised in previous studies since their placement may have impacted participants' level of comprehension differently (Capraro, 2023; Capraro & Cococcioni, 2016; Goeshl & Lohse, 2018). In the future, it would be important to systematically analyze the differences between presenting time constraints solely in the decision and instructions screens.

5.3.4. Participants

Regarding the participants in our studies, it is important to note that the four experiments reported were conducted in WEIRD environments (western, educated, industrialized, rich, and democratic; see Henrich et al., 2010). Most were women, university students (even in the online study regarding COVID-19), and, from the analysis of the SVO employed in the second and third studies, most participants were prosocial. Research has suggested that in this specific context, the observation of the SHH was more likely since these studies were applied in a relatively cooperative and trusting environment (Rand et al., 2014; Rand & Kraft-Todd, 2014). Although using students as participants may limit external validity to some extent, it is a common practice in the field. Even though most studies recurred to student samples majoring in the social and behavioral sciences, a recent meta-analysis revealed that the type of discipline did not affect cooperation (Yuan et al., 2022). The authors found that over the years of research in the US, there seems to be a general increase in cooperative behaviors among strangers and young adults (Yuan et al., 2022). Although most of our sample across studies is composed of university students majoring in psychology, based on these results, the type of discipline may not have a particular increase in cooperation. The evidence found for SHH in our studies is significant because it contradicted the numerous failed studies in recent years and shows that the SHH is valid, particularly in specific contexts where social heuristics for cooperation are stronger. Our studies demonstrated that the SHH was valid, but its applicability was limited to relatively uncertain contexts and a specific population type.

We should also acknowledge that our studies did not systematically investigate the effects of gender on cooperation and its interaction with time pressure manipulation. Future studies should systematically study these effects and explore the effects of group composition. Considering this concern for future research, we should note that previous research did not find an overall gender effect on cooperative behaviors (Balliet et al., 2011; Spadaro et al., 2023). However, studies have demonstrated interesting results regarding the gender composition of interacting partners on the decisions to cooperate or defect (Balliet et al., 2011; Cigarini et al., 2020). Balliet and colleagues' (2011) meta-analysis showed that women are more cooperative in interactions involving the other gender in social dilemmas, while men cooperate more in same-sex interaction pairings than women (Balliet et al., 2011). Additionally, findings suggested that men became more cooperative in repeated interactions than women (Balliet et al., 2011). This study also revealed that in repeated interaction, women followed a tit-for-tat strategy in social dilemmas and exhibited a lower acceptance of defective behaviors, mainly when playing with the same partner (Balliet et al., 2011). In a recent study regarding the influence of eye contact on individuals' beliefs and cooperative behavior revealed that men showed more difficulty in trusting other men, while

women demonstrated higher accuracy in predicting men's behavior (Cigarini et al., 2020). Moreover, cooperation and trust levels improved when interacting partners had different genders and individuals accomplished the best possible collective result (Cigarini et al., 2020). Furthermore, regarding the effect of intuition, previous studies did not find a significant interaction between gender and intuition in studies investigating cooperative behavior (Rand, 2017). However, this research did not investigate the composition of the gender pairings. Considering the effects of gender pairings on cooperation, it would be interesting if future research investigates the effects of group composition on only-men interactions, only-women interactions, and mixed-gender interactions and how they affect cooperation under uncertainty and time pressure conditions.

Determining whether intuition independently promotes cooperation or enhances intrinsic predispositions is essential (Alós-Ferrer & Garagnani, 2020). Specifically, previous research and our studies have only examined these interaction effects in a correlational manner. Further research should investigate the interaction effect of intuition with individual predispositions and systematically examine individual differences in response to uncertainty in cooperative games.

Previous research has suggested that time pressure favors socially desirable reactions (Protzko et al., 2019). In addition, Isler and Yilmaz's (2022) study found that a socially desirable answer is associated with lower ratings in cognitive reflection performance. Taking into account these effects, we considered socially desirable answers as an essential aspect that requires further study, particularly in online experiments. For example, a more socially desirable answer may have interfered with our Study 3 results regarding prosocial behavior under COVID-19 uncertainty. Some individuals may have displayed social desirability bias, claiming that they would invest more in protective behavior when, in other circumstances, they would have not. Nevertheless, in our study, to avoid the potential effects of socially desirable traits, we randomly assigned participants to conditions (as in Isler and Yilmaz, 2022). However, considering previous studies' concerns, future research should consider this effect on participants' cooperative responses. As Isler and Yilmaz (2022) suggested, it will also be important to study socially desirable responses in different moral circumstances. Additionally, socially desirable responses should be studied when there is higher public scrutiny to adhere to prosocial behavior (e.g., during COVID-19) compared to another infectious disease with less public scrutiny (e.g., the flu).

5.3.5. Feedback and Expectations of Cooperation

In the repeated games developed in this dissertation and in previous research (Bereby & Roth, 2006; Gong et al., 2009), participants always received a full feedback screen, which provided information

about the actions taken by the other player, as well as the payoffs received and the cumulative number of points until that moment. This feedback may have contributed to the increased cooperation by diminishing social uncertainty and developing strategies such as conditional cooperation. Therefore, it would be important for future research to address the effects of receiving full feedback in the games developed and compare the results found with those obtained when receiving partial or no feedback. For example, in the study conducted by Kunreuther et al. (2009), besides introducing a full feedback SPD game, they also applied a partial feedback SPD game where individuals obtained feedback only about their opponent's payoffs but not on their decisions to invest or not. Moreover, results from Kunreuther et al. (2009) reported that participants cooperated more in an SPD game with full feedback than in a stochastic game with partial feedback. Based on these findings, we may expect that cooperation rates would decrease in this context of partial feedback and no feedback and, therefore, increase outcome and social uncertainty. Hence, it would be interesting to understand the effects of time constraints in these games with partial or no feedback.

Studies have indicated that individuals frequently use decision time to assess the behavior of those who cooperate and make predictions about others' intentions (Evans & Rand, 2019). In future research, we should also analyze the effects of the expectation of cooperative behavior, similar to the study by Isler et al. (2021). In a study by Evans and van de Calseyde (2017), the authors analyzed how individuals used observed decision time to estimate the behavior of others. Results revealed that participants considered quick decisions more extreme than delayed ones and assumed that fast decisions are either selfish or cooperative (Evans & van de Calseyde, 2017). In this manner, participants also made more extreme choices when playing with an opponent who decided quickly (Evans & van de Calseyde, 2017). The authors highlighted that decision time is vital in forming expectations of others' cooperative behavior (Evans & van de Calseyde, 2017). Participants' attitudes about decision time were influenced by whether time can be recognized as the individual response times or due to external time constraints (Evans & van de Calseyde, 2017). Research has indicated that self-paced decision time is more often associated with feelings of conflict than with intuition or deliberate thinking (Evans & Rand, 2019). When an individual is highly motivated to cooperate or defect, there is little conflict, and in this case, individuals make more fast decisions (Evans & Rand, 2019). In contrast, when the decision-maker has ambiguous preferences, there is more conflict, resulting in a more extensive decision-making process (Evans & Rand, 2019). The relationship between self-paced decision time and cooperation suggests an inverted U relationship (Capraro & Cococcioni, 2016; Evans & Rand, 2019).

In the future, it would also be interesting to analyze if the participants' perception of the amount of time that other players spent on the feedback screen affected the expectation of cooperation, and consequently the participant's cooperative decision. In our game task paradigm, the decision screen only appeared after all participants had seen the feedback screen. Therefore, it would be interesting to analyze whether they believed that the time they waited to begin the next round was fast or not. Alternatively, we could manipulate the time participants waited until the start of the new round after seeing the feedback (i.e., the time that participants perceived that the other players were on their feedback screen). This manipulation would allow us to analyze the effects on the expectations of cooperation and the participants' cooperative decisions.

Given our interest in studying the effects of cognitive manipulation on cooperation under uncertainty, as already mentioned, it will be important for future research to explore the effects found in our studies using other cognitive manipulation methods. We suggest conducting a similar experiment to the ones presented but using a more ecological context, such as a workplace setting. Instead of using time pressure manipulation, one possible suggestion that could have significant practical implications is for participants to use either their second or native language in a social dilemma under uncertainty. As most organizations nowadays have a multicultural workplace, individuals are often required to make cooperative decisions under uncertainty using their second language. Previous research suggested that using a foreign language as a conceptual priming manipulation leads individuals to make more deliberative decisions due to reduced affective and biased responses (Capraro, 2023; Costa et al., 2014). Regarding the interaction effect of the second language and cooperation, Urbig et al. (2016) found that speaking a foreign language (English) instead of one's mother tongue (Dutch) decreased cooperation and reduced positive reciprocity in a repeated PGG. Later, Gargalianou et al. (2017), in a repeated PD with or without feedback, showed that language might not significantly affect behavior without considering interaction effects with gender (Gargalianou et al., 2017). Furthermore, the authors also revealed more cooperation in uncertain conditions concerning the other player' cooperative behavior (Gargalianou et al., 2017). In the next section, we will then discuss some practical implications of the studies developed within this doctoral thesis and that, with the help of further research, could be essential for understanding several mechanisms of our lives.

5.4. Pratical Implications

The findings presented in this doctoral thesis enhanced our comprehension of the cognitive processes involved in cooperative decision-making within real-world contexts. The manipulations

developed have significant implications for real-world contexts since most cooperative decisions are made in circumstances that involve time constraints and some level of uncertainty. We also consider studying the effects of gains and loss frames essential since many real-life situations imply minimizing losses and maximizing gains (Evans & van Beest, 2017). Therefore, our studies focused on cooperative decisions made under risk and uncertainty, considering both the loss and gain frames, to provide further insights into contexts that we encounter daily.

In the studies developed in a laboratory setting (Studies 1 and 2), the games used corresponded to those developed within the IDS game. Previous research in this field has identified several real-life contexts that fit into the IDS framework, such as: a) investing in airline security, b) protecting oneself against diseases through vaccinations, c) investing in cyber security, and d) divisions of firms taking risk-reducing actions to prevent significant losses that could lead an entire firm to bankruptcy (Heal & Kunreuther, 2005; Kunreuther & Heal, 2003; Kunreuther et al., 2009)

In the study of COVID-19 (Study 3), we made a practical application of the variables manipulated in a laboratory setting, namely time pressure, and uncertainty. As such, these results could also be valuable to other medical decisions, such as those related to infectious diseases that require isolation or other protective measures (as demonstrated in the study of Kappes et al., 2018). For example, it would be interesting to understand if individuals would have less prosocial behavior if the infectious disease were not as known as COVID-19, even if it carried the same level of uncertainty and impact on others (e.g., polio or poliomyelitis). In addition, these results could also be applied to emergency decisions where there is a risk associated with cooperating and helping others. In a previous study, a social dilemma known as the help-or-escape game was used to study how much risk individuals are willing to take to assist others in emergencies under time pressure conditions (Moussaïd & Trauernicht, 2016).

Our findings may also be applied to contexts where individual decisions have social consequences (e.g., teamwork; Jarke-Neuert & Lohse, 2022). Specifically, our results could have interesting applications in contexts prone to time constraints, such as organizational settings (e.g., where individuals are required to cooperate with others on a project with a fixed deadline and where there is often uncertainty about the project outcome). These results could also be applied to mediation and negotiation (Ordóñez et al., 2015; Parks, 2004). For instance, in a negotiation context, there is often a deadline to reach a consensus for both parties, and there is uncertainty regarding whether the other parties will decide or not to accept and what will be the result of the negotiation (Ordóñez et al., 2015; Parks, 2004).

Another methodological implication is related to anxiety since choosing under a deadline or feeling pressured can trigger symptoms associated with this disorder, potentially affecting decision-

making (Alós-Ferrer & Caragnani, 2020; Maule et al., 2000). Additionally, a recent study investigated the learning patterns under uncertainty in individuals with anxiety (Lamba et al., 2020). The authors found learning differences in social contexts under uncertainty, suggesting that individuals with anxiety increase their investment decisions when playing with a partner who always defects (Lamba et al., 2020). The study also emphasizes the importance of future research to continue investigating the relationship between learning patterns and uncertainty perception in anxiety disorders (Lamba et al., 2020). Considering this suggestion for future research and the potential effect of time constraints, it would be important to further develop our studies into more applied contexts, such as clinical psychology. In particular, psychologists should consider the impact of time pressure and/or uncertainty on individuals with anxiety to better understand how they deal with the complexity of their daily lives and how their decisions are influenced by it.

Our findings can also be relevant for a deeper understanding of the variables that affect environmental settings (Brozyna et al., 2018; Jarke-Neuert & Lohse, 2022; Lohse et al., 2017). Previously, research has addressed environmental questions using social dilemmas, such as resource dilemmas and public goods games, by manipulating outcome uncertainty (Brozyna et al., 2018; De Kwaadsteniet et al., 2007; Lohse et al., 2017). By applying the knowledge gathered from our studies using social dilemmas in uncertainty and time pressure settings, policymakers could make more effective interventions to incentivize/nudge individuals to implement more sustainability practices. As previously suggested, future research should develop these concepts by extending the research to study groups and group representatives, as in the study of Atanasov and Kunreuther (2016) and Gong et al. (2009). This suggestion is critical, particularly in environmental settings, where politicians must implement more pro-environmental measures to mitigate climate change and develop/meet global treaties. In addition, a group effort is needed to mitigate climate change effectively. Considering this, further research should understand the decisions that individuals make within a group and those made by a group. Overall, we suggest that applying research findings to real-world contexts is essential for advancing our understanding and improving our ability to manage uncertainty effectively and make cooperative decisions under time constraints.

5.5. Conclusion

This doctoral thesis contributes to the study of cognitive processes that underlie cooperative decisions in conditions involving some level of risk and uncertainty through the experimental manipulation of time pressure. In addition, it sheds light on contradictory findings about the effects of cognitive

processing manipulation on prosocial behavior (Capraro, 2023). Previous research has focused essentially on intuition and prosocial behavior, using social dilemmas in which the effects of decisions on the outcomes of other participants are relatively evident (Jarke-Neuert & Lohse, 2022). Our findings indicated that time pressure manipulation enhances cooperative decisions even in relatively uncertain situations. Accordingly, it suggested that time pressure helps individuals make cooperative decisions by default when faced with uncertainty about the decisions of others, outcomes, or when processing complex information. Furthermore, our results proposed that individuals tend to cooperate more and risk less under time pressure. The research developed provides insights into how different factors influence cooperative behavior in social dilemmas.

We consider that we made a small yet essential contribution to the literature. The studies developed have filled a gap in the literature by comparing fast and deliberative cooperative decisions in relatively uncertain contexts. However, it is important to remember that our results are context-restricted, and as we have argued in this chapter, a significant amount of research still needs to be developed. Future research could examine whether previous findings are valid for other types of social dilemmas and other types of environmental uncertainty manipulations. Moreover, it would be important that future studies analyze our findings with other cognitive process manipulations or focus more on using effective reflective manipulation and control conditions. In the present dissertation, we attempted to address the relationship between cooperation under uncertainty and time pressure. By doing so, this dissertation has provided a more comprehensive view of the effects of cognitive underpinnings of cooperation under relatively uncertain situations.

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APPENDIXES

Appendix A: Instructions, Stimuli, and Supplementary Information of Study 1

A.1. Study 1: Instructions

Table A.1

Instructions for the Main Task of Study 1

	Instructions
General Instructions	In this study, we recruit students to resolve several problem-solving challenges! Initially, you will play a game in which the outcomes of your decisions depend not only on what you choose to do but also on what your counterpart does. Your counterpart in this game will be the other participants present in the experimental room. Still, you will not know who the other participants are, and they will not know about your identity. You will play multiple sessions. In each session, you will play against the same counterpart in one Supergame (that has 10 rounds), then switch counterparts in the next Supergame. At the beginning of each supergame, all participants will be given 1500 points. In this game, we simulate a situation in which avoiding more significant losses is essential. Therefore, each of you will decide independently whether or not to invest some of your initial 1500 points to lose as few points as possible. Please keep in mind that the experiment cannot continue until all participants make their decisions. You will not know the decision your counterpart has made until the end of each round. Before starting the next round, you will be given feedback on what you and your counterpart did in this round and the status of your points. The score at the end of each round is essential since it will later determine the reward you might receive at the end of this study. Specifically, two participants will be randomly selected to receive a gift card of a value proportional to the points from one random supergame (the exchange rate is 1 point for 0.03 cents - 1500 points = 45 euros). The amount of points you keep at the end of each supergame is your payoff for that supergame. The final payoffs might depend on one random Supergame. To illustrate, suppose someone is randomly chosen to be paid for their Supergame 4. Suppose at the end of Supergame 4, they have 900 points. At the end of the experiment, this person will receive 27 euros. Raise your hand if you have any questions regarding the experiment. We will then come directly to your place. Otherwise, please press the "*Continue*" button to read the following instructions regarding the game's rules.
	In each round, you have to choose one out of two alternative decisions, INVEST and NOT INVEST. Depending on your opponent's decision, your payoff is then determined according to the table below. You find your own payoff at the first position of each item and the payoff of your opponent in the second position. ————————[Stochastic Prisoner's Dilemma (SPD)]———————— • If both you and the other player choose to INVEST, then it will cost each of you 45 points. • If one of you chooses to INVEST and the other chooses NOT INVEST. In that case,

Rules of the game

- the one who chooses INVEST loses 45 points and has a 20% probability of losing additional 100 points. That is, the investor has a 20% probability of losing 145 points and an 80% probability of losing 45 points,

and,

- the other who chooses NOT INVEST has a 40% probability of losing 100 points and a 60% probability of not losing any points.

- If both of you choose NOT INVEST, then each of you will have a 52% probability of losing 100 points and a 48% of not losing any points.

The table illustrates the four possible outcomes:

		Your counterpart: Invest	Your counterpart: Not Invest
You	Invest	-45; - 45	• 20% lose 145, 80% lose 45; • 40% lose 100, 60% lose 0
	Not Invest	• 40% lose 100, 60% lose 0; • 20% lose 145, 80% lose 45	• 52% lose 100, 48% lose 0; • 52% lose 100, 48% lose 0

———————————————————————————————

————————————[Deterministic Prisoner's Dilemma (DPD)]————————————

- If both you and the other player choose to INVEST, then it will cost each of you 45 points.
- If one of you chooses to INVEST and the other chooses NOT INVEST.
  In that case,
  – the one who chooses INVEST loses 60 points,
  and,
  – the other who chooses NOT INVEST loses 40 points.
- If both of you choose NOT INVEST, then it will cost each of you 52 points.

The table illustrates the four possible outcomes:

		Player 2: Invest	Player 2: Not Invest
Player 1	Invest	-45; -45	-60; -40
	Not Invest	-40; -60	-52; -52

———————————————————————————————

The information present in the table will appear in every round. Please raise your hand if you have any questions.

Instructions on time

[Time pressure condition] Please make your decision as quickly as possible. You must make your decision in less than 10 seconds!

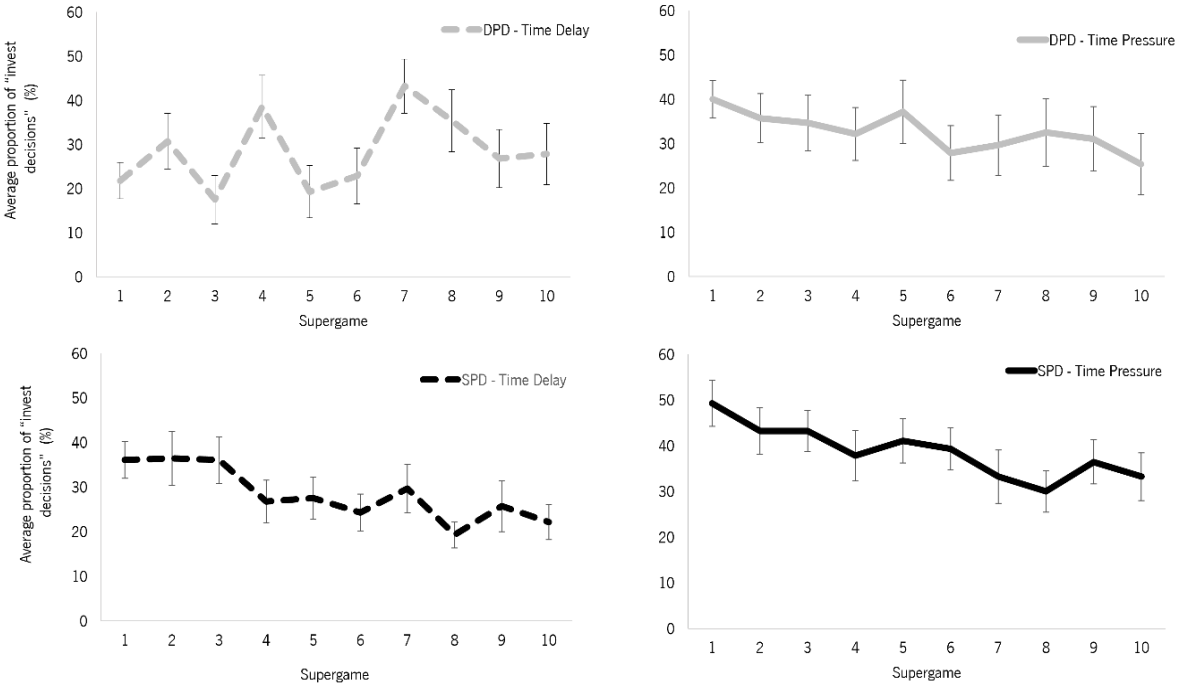
[Time delay condition] Please carefully consider you decision. You must wait and think for at least 10 seconds before making your decision.

Please click "Continue" when you are ready to start the experiment.

A.2. Study 1: Supplementary Material

Figure A.2.1

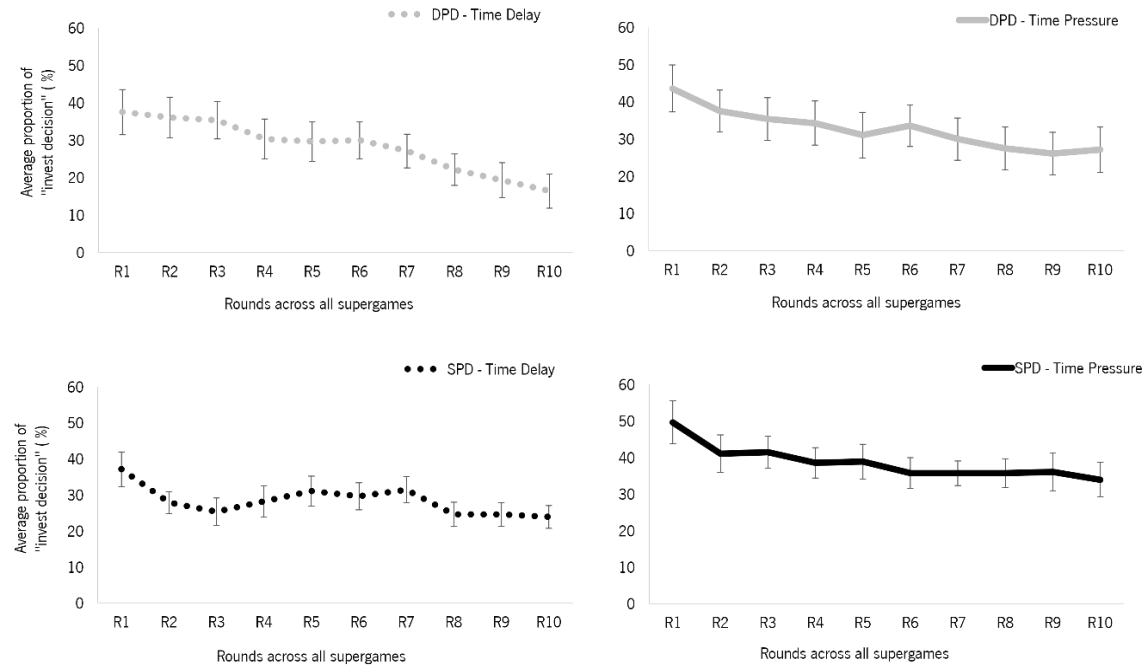
Cooperation Rates Across the Ten Supergames Played in the Four Conditions



Note. n = 28 participants in each graphic presented. Error bars represent standard errors of the mean.

Figure A.2.2

Cooperation Rates Across the Rounds Played in All Supergames in the Four Conditions



Note. n = 28 participants in each graphic presented. Error bars represent standard errors of the mean.

A.3. Study 1: Stimulus

Figure A.3

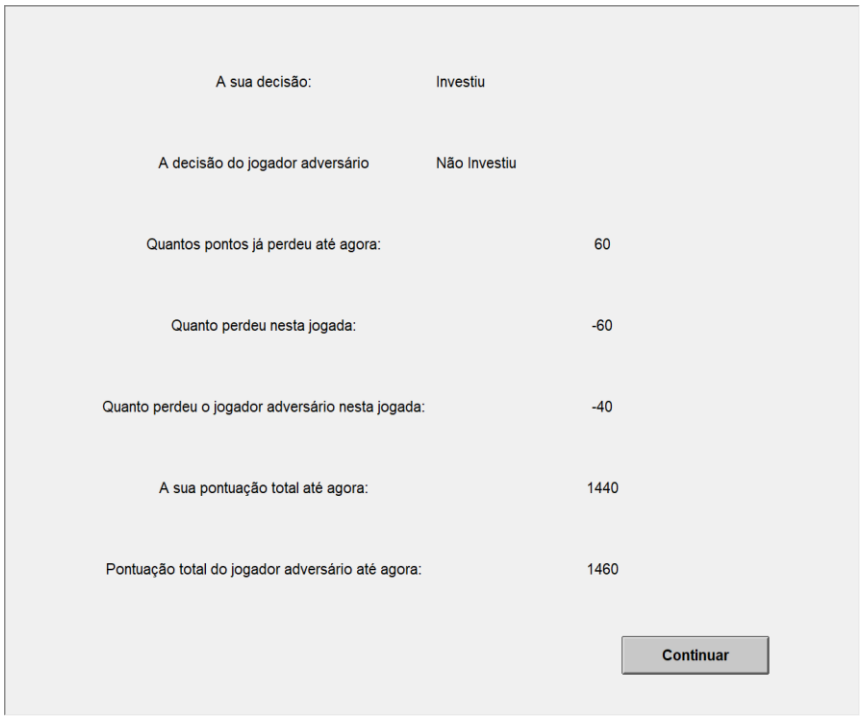
Participant's View of the Decision and Feedback Screen in the Main Task of Study 1



Note. Example of the DPD game under a time delay condition.



Note. Example of a DPD game under time pressure condition.



Note. Example of a feedback screen in a DPD condition.



Note. Example of SPD game in a time pressure condition.

A.4 Supplementary Notes

We conducted a forward and backward stepwise multiple linear regression to evaluate if individual differences influence the average cooperative behavior. The individual differences that we analyzed were: i) personality factors from the Big Five Inventory; ii) the four dimensions from the empathy scale; iii) the positive and negative affect previous and after the experiment; iv) the individual risk-taking propensity calculated by the average number of pumps for all unexploded balloons; v) sociodemographic variables:

age, sex, socioeconomic status, and given that all participants are university students, the year they were enrolled; vi) and game-related questions: how much they rated their day-to-day basis cooperation with the other players, how much participants rate they are close (proximity) with the other players, the difficulty experienced during the execution of the task, understanding the task and the instructions, how stressful was the execution of the task, and rate how pleasant was the performance of the task.

Conducting the most parsimonious model (the second model - with the lowest AIC - Akaike Information Criterion = -371.66), we found that some of the individual difference measures were statistically significant predictors of the average proportion of cooperation $F(12,99) = 5.65$, $p < .001$, $R^2_{adj.}$ =.33. Table 1 reveals that in the second model, the neuroticism trait of personality is a significant negative predictor of the average proportion of cooperation (β = -.014, t = -3.84, p < .001, OR = .99, 95 % CI [.98, 99]). At the beginning of the experiment, the negative affect revealed a significant effect (β = .029, t = 2.94, p = .004, OR = 1.03, 95% CI [1.01,1.05]). Additionally, at the end of the experiment, the positive affect revealed a significant effect (β = .019, t =3.28, p = .001, OR = .99, 95% CI [.97, 1.00]) on the average proportion of cooperation. We applied two independent t-tests to compare the positive affect previous and after the experiment and found a statistical difference $t(111) = -5{,}259$, $p \leq .001$. Positive affect improved at the end of the experimental task. We found no statistical differences between the negative affect previous and after the experiment ends $t(111) = .729$, p = .468.

The model revealed a marginally significant effect on the average number of pumps in the BART task (β = .002, t = 1.78, p = .077, OR = 1.00, 95% [1.00, 1.01]). Regarding the sociodemographic variables, the socio-economic value is a statistically significant predictor of the average probability of cooperation. Participants who report having a medium-high socio-economic value (n = 15) have a higher average probability of cooperation (β = .199, t = 3.44, p < .001, OR = 1.22, 95% [1.09, 1.37]). Two questions regarding the execution of the task revealed to be a statistically significant positive predictor of the average probability of cooperation: how pleasant was the execution of the task (β = .031, t = 2.79, p = .006, OR = 1.03, 95% [1.01, 1.05]) and the difficulty experienced (β = .029, t = 2.23, p = .028, OR =1.03, 95% [1.00, 1.06]). Moreover, the question regarding how stressful the task's execution is was revealed to be a marginally significant predictor (β = .023, t = 1.95, p = .054, OR = 1.02, 95% CI[1.00,1.05]). Additionally, the model revealed that men (n=24) are a significant predictor of the average probability of cooperation (β = .097, t = 2.12, p = .036, OR = 1.10, 95% CI[1.01,1.20]).

Table A.2

Multiple Linear Regression on the Average Cooperation Rate

	Model 1			***Model 2***		
	β (SE)	*t*	*p*	*β (SE)*	*t*	*p*
Intercept	-.30(.39)			-.07(0.15)		
Positive Affect	-.01(.01)	-1.68	.096	-.01(.01)	-1.74	.086
Negative Affect	.02(.01)	1.48	.142	.03(.01)	2.94	.004**
End_Pos Affect	.02(.01)	2.68	.009	.02(.01)	3.28	.001**
End_Neg Affect	.01(.02)	.69	.493			
BFI_neuroticism	-.01(.00)	-2.63	.026	-.01(.00)	-3.84	<.001***
BFI_extraversion	.00(.01)	.91	.367			
BFI_agreeableness	-.00(.00)	-.44	.659			
BFI_conscientiousness	.00(.00)	.25	.800			
BFI_openness	-.00(.00)	-.29	.770			
Empathy_PT	.01(.01)	1.26	.212			
Empathy_EC	-.00(.01)	-.55	.583			
Empathy_PD	.01(.01)	.87	.385			
Empathy_F	-.00(.01)	-.10	.922			
BART-Average_Pump	.00(.00)	1.79	.076	.00(.00)	1.78	.077
Age	-.00(.01)	-.31	.759			
Gender	.12(.06)	2.16	.033	.10(.05)	2.12	.036*
SES Level 3	.05(.04)	1.03	.305	.04(.04)	1.14	.257
SES Level 4	.21(.06)	3.28	.002	.20(.06)	3.44	<.001***
Year of school	.01(.02)	.71	.481			
Cooperate	-.01(.01)	-1.03	.306	-.01(.01)	-1.48	.143
Proximity	.00(.02)	.19	.848			
Difficulty experienced	.03(.02)	1.95	.055	.03(.01)	2.23	.029*
Understanding of the task	-.02(.02)	-1.00	.316			
Stressful	.02(.01)	1.72	.090	.02(.01)	1.95	.054
Pleasant	.03(.01)	2.36	.020	.03(.01)	2.79	.006**
N	112			112		
F(df)	2.63(25,86)			5.65(12,99)		
Multiple R^2	.43			.41		
Adjusted R^2	.27			.33		

Note. β = coefficient; SE = standard error of the coefficient.

* p <.05. ** p <.01. *** p <.001.

Discussion

Following the suggestion of previous research (Alós-Ferrer & Garagnani, 2020) in our experiment, we also explored the degree to which individual determinants affect cooperative behavior. Specifically, we explore if the individual risk-taking propensity predicts the previous task's cooperation rate. The score in the BART task was computed by averaging the number of pumps for all unexploded balloons (Lejuez et al., 2002; Liu et al., 2021). A higher BART score indicated a higher level of risk-taking (Liu et al., 2021). Results demonstrated that the more risk-taking propensity an individual presents, the more he cooperates in the game task. We found a marginally significant effect that suggests that individuals with a higher risk-taking propensity would cooperate more. Literature supports these findings, revealing that risk-seeking individuals were more cooperative than risk-averse individuals (Fung et al., 2012; Parks et al., 2004; Thielmann et al., 2020).

In our study regarding personality traits, lower levels of neuroticism predict the likelihood of cooperation in the prisoner's dilemma. Neuroticism is defined as the trait disposition to experience negative effects. It involves vulnerability to stress and the experience of negative emotions (e.g., anxiety, hostility, and depression; McCrae & Costa, 1987). The result found is consistent with previous research revealing that lower neuroticism levels predicted higher cooperation levels in the incentivized prisoner's dilemma game (Lönnqvist et al., 2011). Previous findings also report a positive but not significant effect between neuroticism and cooperation in a hypothetical game. The negative effect of neuroticism on cooperation was also found in other social dilemma games (Fahr & Irlenbusch, 2008; Zhao & Smillie, 2015). A study revealed that neuroticism is a good predictor of risk-taking among personality factors in a loss domain (Lauriola & Levin, 2001). Additionally, contrary to previous findings, we do not find an effect of the other personality traits on predicting cooperative behaviors: openness to experience (Lönnqvist et al., 2011), extroversion (Hirsh & Peterson, 2009), and agreeableness (Kagel & McGee, 2014; for a review, see Thielmann et al., 2020; Zhao & Smillie, 2015). Relatively to mood effects, our results demonstrate an increase in the positive affect reported at the end of the experiment, compared with the beginning. Also, the positive affect at the end of the game task significantly predicts the average cooperation rate. The more positive affect reported at the end of the experiment, the higher the average cooperation rate. Previous research suggests that a positive mood increases cooperative and prosocial behavior (Hertel et al., 2000; Kirchsteiger et al., 2006; Lount, 2010). Most studies have explored the relationship between mood and prosocial behavior by inducing people to be in a positive, negative, and neutral mood (Hertel et al., 2000; Kirchsteiger et al., 2006; Lount, 2010). Our study only asks people to rate their current mood to control their dispositional mood at the time of the experience. Additionally, we found an interesting effect that the negative affect reported at the beginning of the experiment is a significant predictor, which means that individuals who report more negative affect at the beginning of the experiment have a higher average cooperation rate.

Regarding sociodemographic variables, socioeconomic status is revealed to be a significant predictor of the individual cooperation mean, revealing that participants who report a medium-high socioeconomic status cooperate more. However, few students reported having a medium-high socioeconomic status (n =18), and most indicated a medium socioeconomic status (n = 64). Additionally, two game-related questions were revealed to be significant predictors of the individual average propensity to cooperate. The difficulty experienced and the pleasure experienced during the task was revealed to be

significant positive predictors of the average cooperation rate. The more difficult participants evaluated the task, the more they cooperated. In addition, the more participants perceived the task as unpleasant, the more they cooperated (on a Likert scale ranging from 1 = pleasant to 7= unpleasant). However, the mean values revealed that participants perceived the task as pleasant (Mean from all groups = 3.63), and participants in the SPD time delay condition rated the perceived unpleasantness of the task higher (*M*=4.04, *SD*=1.32). The variable of participants' perceived stress level during the game task revealed a marginally significant effect on the average propensity to cooperate, measured on a Likert scale ranging from 1 (stressful) to 7 (relaxed). As participants perceived the task as less stressful, their propensity to cooperate increased. However, significant differences were observed among the groups concerning how stressful they perceived the task ($\chi 2(3) = 8.76$, $p = .033$). Subsequent Dunn's post hoc tests revealed differences between the DPD time delay group, which perceived the game task as less stressful (*M* = 5.04, *SD* = 1.73) than participants in the SPD time pressure condition (*M* = 4.25, *SD* = 1.30), and compared to the SPD time delay group (*M* = 4.00, *SD* = 1.44). Furthermore, participants in the DPD time pressure (*M* = 4.75, *SD* = 1.46) considered the condition less stressful compared to participants in the SPD time delay group. We also found a significant main effect of gender, such that men seem to be a significant predictor of the average cooperation rate. Previous research did not find an overall effect of gender on the decision to cooperate (Balliet et al., 2011). It is important to note that we have analyzed the average cooperation rate, not the decision to cooperate. Findings from Balliet et al. (2011) meta-analysis revealed that over time (in repeated interactions), men became more cooperative than women, and our study 1 was a repeated game.

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Appendix B: Stimuli and Supplementary Information of Study 2

B.1. Study 2: Sociodemographic Variables

Table B.1

Description of the Sociodemographic Variables of Study 2

		1st Experiment	2nd experiment
Personal Characteristics	Level	*n* (%)	*n* (%)
Gender	Men	61 (31.8)	62 (32.3)
	Women	131 (68.2)	130 (67.7)
Nationality	Portuguese	176 (91.7)	179 (93.2)
	Brazilian	9 (4.7)	7 (3.6)
	Portuguese-Luxembourgish	7 (3.6)	0(0.0)
	Santomean	0(0.0)	1(0.5)
	South African	0(0.0)	1(0.5)
	Cape Verdean	0(0.0)	1(0.5)
	Angolan	0(0.0)	2(1.0)
	Portuguese-Canadian	0(0.0)	1(0.5)
Course	Public administration	3(1.6)	0(0.0)
	Applied Biology	2(1.0)	2(1.0)
	Biology and Geology	7(3.6)	3(1.6)
	Political Science	3(1.6)	0(0.0)
	Communication Sciences	1(0.5)	3(1.6)
	Criminology and Criminal Justice	5(2.6)	8(4.2)
	Fashion design	1(0.5)	0(0.0)
	Law	5(2.6)	5(2.6)
	Economy	6(3.1)	4(2.1)
	Education	1(0.5)	2(1.0)
	Nursing	5(2.6)	4(2.1)
	Biomedical Engineering	6(3.1)	5(2.6)
	Materials Engineering	3(1.6)	0(0.0)
	Polymer Engineering	2(1.0)	1(0.5)
	Information Systems Engineering and Management	2(1.0)	4(2.1)
	Industrial Electronic Engineering and Computers	7(3.6)	3(1.6)
	Computer Science Engineering	21(10.9)	13(6.8)
	Mechanical Engineering	2(1.0)	1(0.5)
	Philosophy	4(2.1)	0(0.0)
	Management	2(1.0)	0(0.0)
	History	4(2.1)	12(6.3)
	Applied Languages	5(2.6)	0(0.0)

	European Languages and Literature	2(1.0)	0(0.0)
	Marketing and Business Communication	1(0.5)	0(0.0)
	Master's in Management and Business	1(0.5)	0(0.0)
	Interuniversity Master's Clinical and Experimental Neuropsychology	2(1.0)	1(0.5)
	Master in Geosciences	1(0.5)	0(0.0)
	Music	3(1.6)	7(3.6)
	International Business	1(0.5)	1(0.5)
	Optometry and Vision Sciences	1(0.5)	7(3.6)
	Psychology	70(36.5)	76(39.6)
	Chemistry	1(0.5)	2(1.0)
	International Relations	2(1.0)	1(0.5)
	Solicitor	1(0.5)	0(0.0)
	Business management	2(1.0)	0(0.0)
	Sociology	5(2.6)	8(4.2)
	Zootechnical Engineering	1(0.5)	0(0.0)
	Biochemistry	0(0.0)	1(0.5)
	Product design	0(0.0)	1(0.5)
	Physical Engineering	0(0.0)	1(0.5)
	Oriental Studies	0(0.0)	1(0.5)
	Physics	0(0.0)	2(1.0)
	Physiology	0(0.0)	1(0.5)
	Marketing	0(0.0)	6(3.1)
	Accounting	0(0.0)	1(0.5)
	Computer Science	0(0.0)	5(2.6)
Year of enrollment	1st Year	62(32.3)	91(47.4)
	2nd Year	42(21.9)	35(18.2)
	3th Year	50(26.0)	41(21.4)
	4th Year	18(9.4)	15(7.8)
	5th Year	18(9.4)	8(4.2)
	PhD	2(1.0)	2(1.0)
Socio-economic status	Low / Medium-Low	56(29.2)	39(20.3)
	Medium	115 (59.9)	129(67.2)
	Medium-high / High	21 (10.9)	24(12.5)

Note. Results are shown in absolute and relative frequencies (%).

B.2. Supplementary Results Experiment 1

In our first model (see SM Table 2), we began by fitting the full summative model (including all predictors and their interactions). In a second model, we introduced the three variables we manipulated in the task and their interaction effect (time manipulation, type of game, and type of frame) and the moderator variable (the socioeconomic status-SES) that revealed a significant effect in the first model (Model 2 in table). In the second model, socioeconomic status did not reveal a significant effect. Additionally, we conducted a likelihood ratio test revealing no difference between the two models ($\chi 2$ (17)= -21.34, p = .211). The data and analysis code are available at https://osf.io/7bsau/.

Table B.2

Logistic Regression for Cooperation Probability in the One-Shot Game

	Model 1	**Model 2**
	β (SE)	β (*SE*)
Intercept	-2.35 (2.15)	-1.27 (0.58)*
Game [DPD]	0.88 (1.06)	1.37 (0.72)
Time manipulation [Pressure]	3.50 (1.13)**	2.30 (0.71)**
Frame [Gain]	0.04 (1.07)	0.57 (0.73)
Game*Time	-2.79 (1.12)*	-1.89 (0.93) *
Game*Frame	-1.21 (1.06)	-0.89 (0.96)
Time*Frame	-0.76 (1.10)	-0.49 (0.96)
Time*Frame*Game	2.01 (1.47)	1.23 (1.29)
SVO[Proself]	-0.14 (0.60)	
SVO[Proself]* Time	-1.29 (0.79)	
Adjusted Values Bart	-0.04 (0.03)	
AdjustedBart*Time	-0.01 (0.03)	
AdjustedBart*Game	0.03 (0.03)	
AdjustedBart*Frame	0.02 (0.02)	
Controls:		
Gender[Male]	-0.03 (0.43)	
Difficulty	-0.01 (0.15)	
Cooperation	-0.11 (0.18)	
Pleasant	-0.08 (0.09)	
Proximity	0.16 (0.19)	
SES[Medium]	-0.98 (0.43)*	-0.67 (0.38)
SES[Medium-High/High]	-0.69 (0.65)	-0.39 (0.56)
IRI_Perspective Taking	0.09 (0.05)	
IRI_Empathic Concern	-0.05 (0.07)	
IRI_Personal Discomfort	-0.04 (0.05)	
IRI_Fantasy	0.02 (0.04)	
PANAS-SF_Positive	0.04 (0.06)	

PANAS-SF_Negative	0.12 (0.08)	
N	192	192
R^2 Tjur	0.251	0.152
AIC	266.3	253.64
Log-likelihood	-106.1479	-116.8189

Note. β = coefficient; *SE* = standard error of the coefficient; *CI* = confidence interval;

AIC = The Akaike information criterion.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Results revealed a significant effect regarding the positive affect $t(191) = -4.86$, $p < .001$, $d = -.350$, suggesting that the positive affect augments at the end of the task ($M = 17.45$, $SD = 3.81$) compared to the positive affect participants reported at the beginning of the task ($M = 16.51$, $SD = 3.27$). Regarding the negative affect, results also revealed a significant effect $t(191) = 2.89$, $p = .004$, $d = .209$) such that the negative affect reported at the end of the task ($M = 6.09$, $SD = 1.80$) diminishes compared to the negative affect participants reported at the beginning ($M = 6.52$, $SD = 2.89$).

B.3. Supplementary Results Experiment 2

Table B.3.1

Logistic Regression Model for Cooperation Probability in the Repeated PD With Round and Supergame as a Factor

	Model 1					
				95 % CI for odds ratio		
	β (SE)	*Z* value	*p*	*LL*	Odds Ratio	*UL*
Intercept	-0.11 (0.11)	-1.03	.301	0.73	0.90	1.10
Game [DPD]	-0.68 (0.10)	-6.74	<.001	0.41	0.51	0.62
Time [Pressure]	0.72 (0.11)	6.84	<.001	1.67	2.06	2.53
Frame [Gain]	0.21 (0.10)	2.05	.040	1.01	1.23	1.50
Game*Time	-0.37 (0.09)	-3.91	<.001	0.58	0.69	0.83
Game*Frame	-1.00 (0.10)	-9.72	<.001	0.30	0.37	0.45
Frame*Time	0.04 (0.09)	0.49	.624	0.88	1.05	1.25
Time*Frame*Game	0.66 (0.14)	4.76	<.001	1.47	1.93	2.53
Round 2	-0.34 (0.07)	-4.88	<.001	0.62	0.71	0.81
Round 3	-0.50 (0.07)	-6.96	<.001	0.53	0.61	0.70
Round 4	-0.44 (0.07)	-6.28	<.001	0.56	0.64	0.74
Round 5	-0.45 (0.07)	-6.32	<.001	0.56	0.64	0.73
Round 6	-0.62 (0.07)	-8.60	<.001	0.47	0.54	0.62
Round 7	-0.62 (0.07)	-8.60	<.001	0.47	0.54	0.62
Round 8	-0.65 (0.07)	-8.93	<.001	0.45	0.52	0.60
Round 9	-0.64 (0.07)	-8.90	<.001	0.46	0.53	0.61
Round 10	-0.74 (0.07)	-10.08	<.001	0.41	0.48	0.55
Supergame 2	-0.23 (0.07)	-3.22	.001	0.69	0.80	0.91
Supergame 3	-0.32 (0.07)	-4.44	<.001	0.63	0.73	0.84
Supergame 4	-0.43 (0.07)	-5.91	<.001	0.57	0.65	0.75
Supergame 5	-0.37 (0.07)	-5.21	<.001	0.60	0.69	0.79

Supergame 6	-0.50 (0.07)	-6.91	<.001	0.52	0.60	0.70
Supergame 7	-0.35 (0.07)	-4.85	<.001	0.61	0.71	0.81
Supergame 8	-0.34 (0.07)	-4.81	<.001	0.62	0.71	0.82
Supergame 9	-0.64 (0.07)	-8.63	<.001	0.46	0.53	0.61
Supergame 10	-0.47 (0.07)	-6.50	<.001	0.54	0.62	0.72
SVO[Proself]	-0.44 (0.05)	-8.20	<.001	0.58	0.65	0.72
SVO[Proself]* Time	0.50 (0.07)	7.14	<.001	1.44	1.65	1.90
Adjusted Values Bart	0.01 (0.00)	3.07	.002	1.00	1.01	1.01
AdjustedBart*Time	-0.02 (0.00)	-5.85	<.001	0.98	0.98	0.99
AdjustedBart*Game	0.02 (0.00)	5.84	<.001	1.01	1.02	1.02
AdjustedBart*Frame	-0.00 (0.00)	-1.24	.216	0.99	1.00	1.00
N	19200					
AIC	21719.8					
BIC	21995.0					
Log-likelihood	-10824.9					

Note. β = coefficient; *SE*- standard error of the coefficient; CI = confidence interval; *LL* = lower limit; *UL* = upper limit; AIC-= The Akaike information criterion; BIC = Bayesian information criterion.

Table B.3.2

Logistic Regression Model for Cooperation Probability in the Repeated PD for the Control Variables and Others' Past Decisions

	Model 1	**Model 2**
	β*(SE)*	β(*SE*)
Intercept	1.30 (0.24)***	0.62 (0.25)*
Game [DPD]	-0.65 (0.11)***	-0.63 (0.12)***
Time manipulation [Pressure]	0.59 (0.11)***	0.30 (0.12)*
Frame [Gain]	0.28 (0.11)**	0.30 (0.12)**
Game*Time	-0.25 (0.10)*	-0.15 (0.11)
Game*Frame	-1.06 (0.11)***	-0.86 (0.12)***
Time*Frame	-0.07 (0.10)	-0.08 (0.10)

Time*Frame*Game	0.55 (0.14)	0.51 (0.16)**
SVO[Proself]	-0.50 (0.05)***	-0.46 (0.06)***
SVO[Proself]* Time	0.56 (0.07)***	0.49 (0.08)***
Adjusted Values Bart	0.01 (0.00)***	0.01 (0.00)*
AdjustedBart*Time	-0.01 (0.00)***	-0.01 (0.00)
AdjustedBart*Game	0.01 (0.00)***	0.01 (0.00)**
AdjustedBart*Frame	-0.00 (.00)	-0.01 (0.00)
Controls:		
Other Past Decision		0.89 (0.04)***
Round	-0.06 (0.01)***	-0.03 (0.01)***
Supergame	-0.04 (0.01)***	-0.03 (0.01)***
Gender[Male]	-0.14 (0.04)**	-0.13 (0.05)**
Difficulty	-0.04 (0.01)**	-0.03 (0.02)
Cooperation	0.04 (0.02)*	0.03 (0.02)
Pleasant	0.04 (0.01)***	0.04 (0.01)***
Proximity	0.00 (0.02)	0.00 (0.02)
SES[Medium]	-0.27 (0.04)***	-0.28 (0.05)***
SES[Medium-High/High]	-0.13 (0.06)*	-0.12 (0.07)
IRI_Perspective Taking	-0.01 (0.01)*	-0.01 (0.01)
IRI_Empathic Concern	-0.04 (0.01)***	-0.04 (0.01)***
IRI_Personal Discomfort	0.01 (0.01)	0.01 (0.00)
IRI_Fantasy	0.00 (0.0)	0.00 (0.0)
PANAS-SF_Positive	-0.04 (0.01)***	-0.04 (0.01)***
PANAS-SF_Negative	-0.01 (0.01)	-0.01 (0.01)
N	19200	17280
BIC	21793.5	18869.0
AIC	21541.9	18613.0
Log-likelihood	-10738.9	-9273.5

Note. β = coefficient; SE = standard error of the coefficient; CI = confidence interval; AIC-=The Akaike information criterion; BIC = Bayesian information criterion.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Figure B.3.1

*Graphic Representation of the Interaction Between Time*Frame*Game*

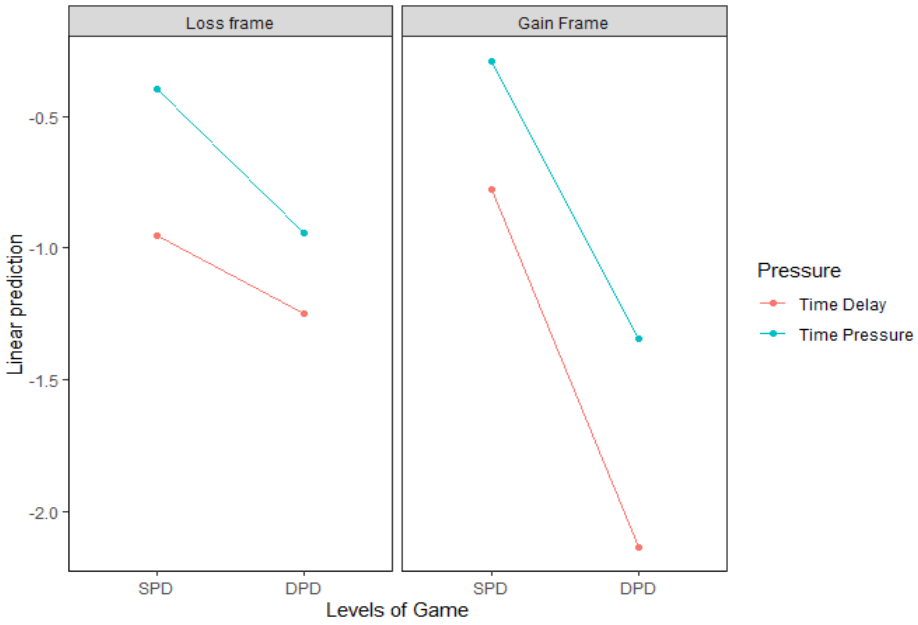


Table B.3.3

*Marginal Effects of the Time*Frame*Game Interaction Effect*

Game	Frame	Time	Contrast	*β*(*SE*)	*p*	95 % CI for odds ratio		
						LL	*Odds Ratio*	*UL*
SPD	Loss		TD-TP	-.54(.06)	<.001	0.52	0.59	0.66
DPD	Loss		TD-TP	-.17(.07)	.149	0.74	0.84	0.96
SPD	Gain		TD-TP	-.58(.06)	<.001	0.49	0.56	0.63
DPD	Gain		TD-TP	-.87(.08)	<.001	0.36	.42	0.49
	Loss	TD	SPD-DPD	.25(.07)	.003	1.12	1.28	1.47
	Loss	TP	SPD-DPD	.61(.06)	<.001	1.63	1.85	2.10
	Gain	TD	SPD-DPD	1.25(.08)	<.001	2.99	3.48	4.05
	Gain	TP	SPD-DPD	.96(.07)	<.001	2.29	2.60	2.95
SPD		TD	Losses-Gain	-.11(.07)	.993	0.78	.89	1.01
SPD		TP	Losses-Gain	-.16(.06)	.105	0.76	.85	0.96
DPD		TD	Losses-Gain	.88(.08)	<.001	2.06	2.42	2.83
DPD		TP	Losses-Gain	.18(.07)	.091	1.05	1.20	1.37

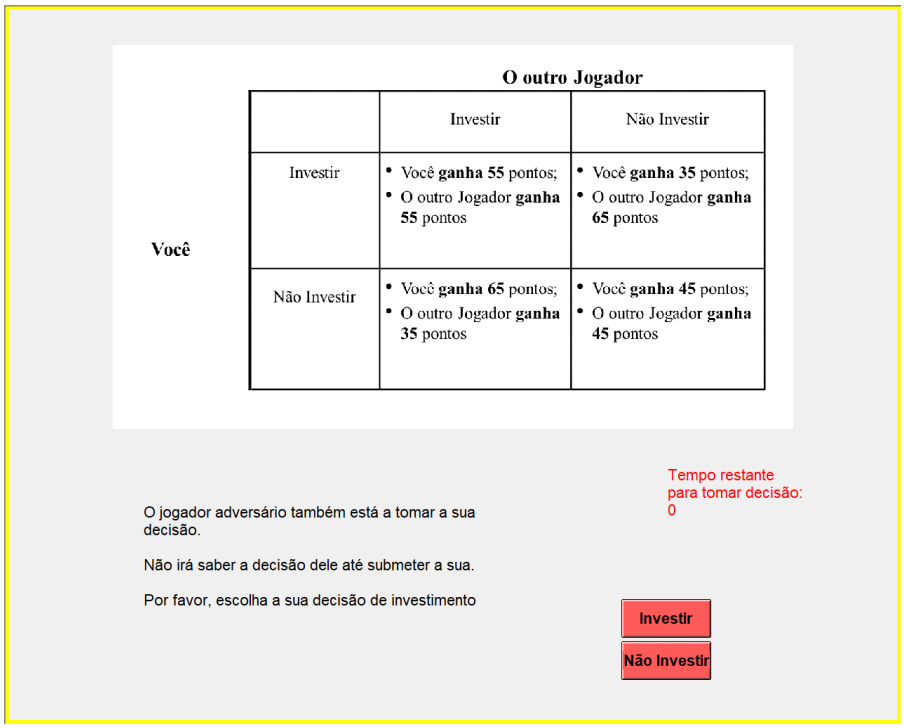
Note. *β* = coefficient; *SE*= standard error of the coefficient; *TP*= Time Pressure; *TD* = Time Delay; *LL* = lower limit; *UL* = upper limit.

Results did not reveal a significant effect $t(191) = -1.01$, $p = .312$, regarding the positive affect at the beginning task (M=16.17, SD=3.17) and at the end of the task (M=16.40, SD=4.20). Regarding the negative affect, results revealed a significant effect $t(191)$=4.17, p<.001, d = .301) such that the negative affect reported at the end of the task (M=5.92, SD=1.81) diminishes compared to the negative affect participants reported at the beginning (M=6.70, SD=2.61).

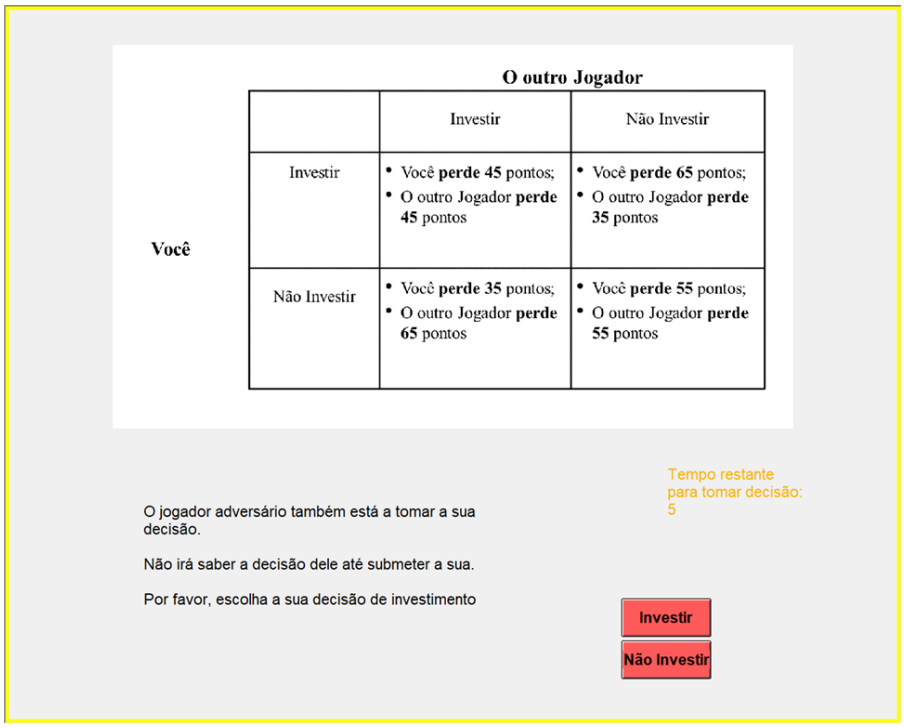
B.4. Study 2: Stimulus

Figure B 4.1

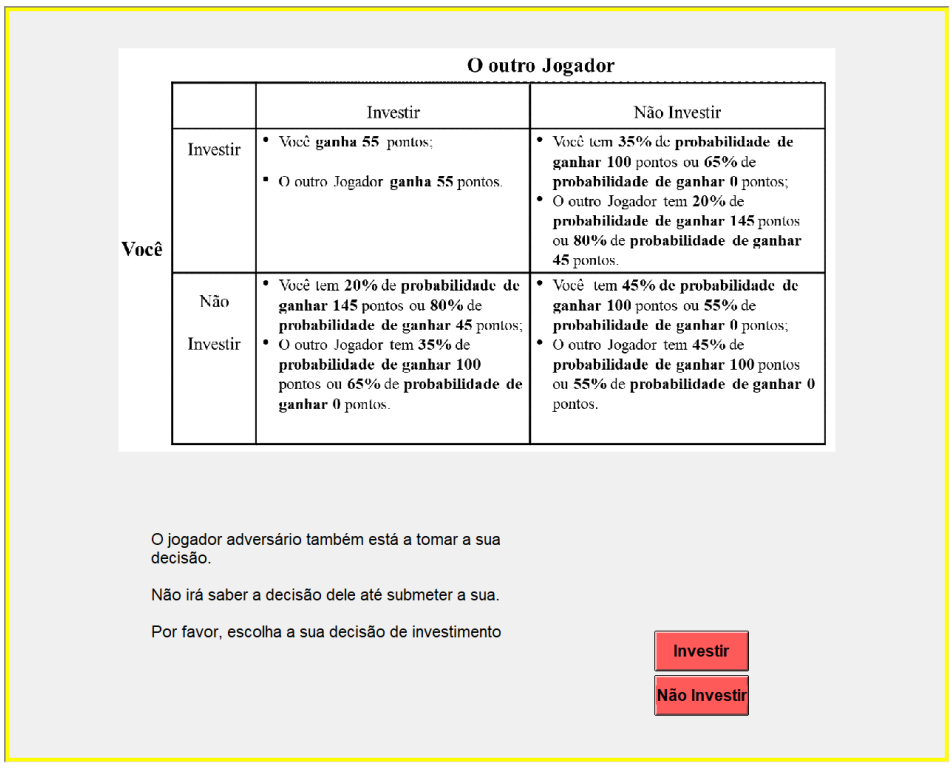
Participant's View of the Decision and Feedback Screen in the Main Task of Study 2



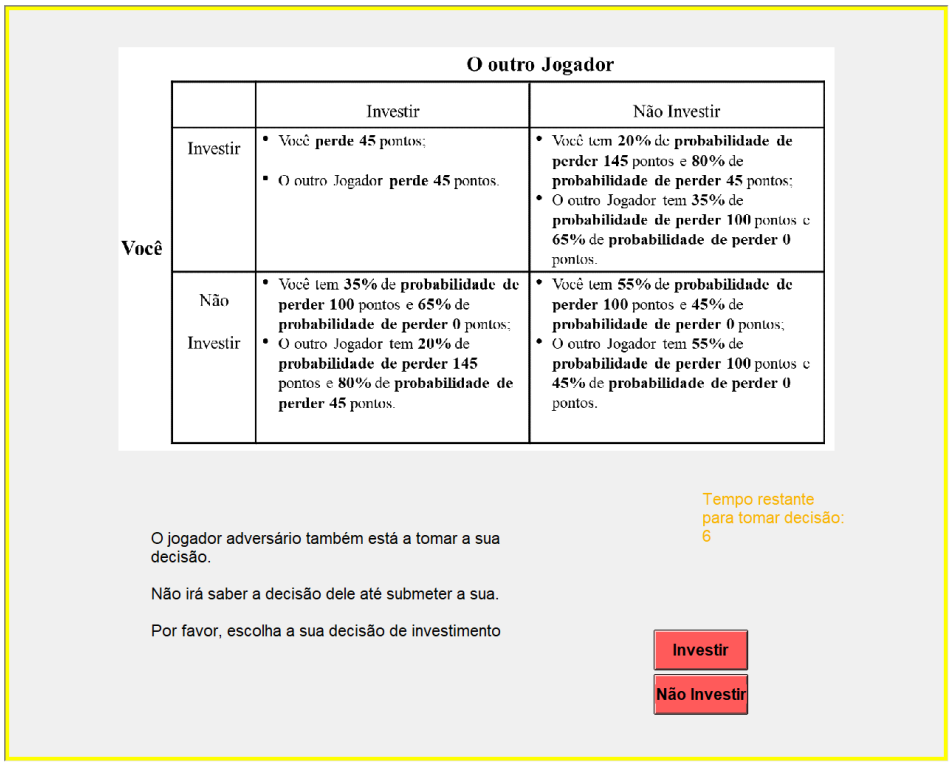
Note. Example of a DPD game in a time pressure within a gain frame condition.



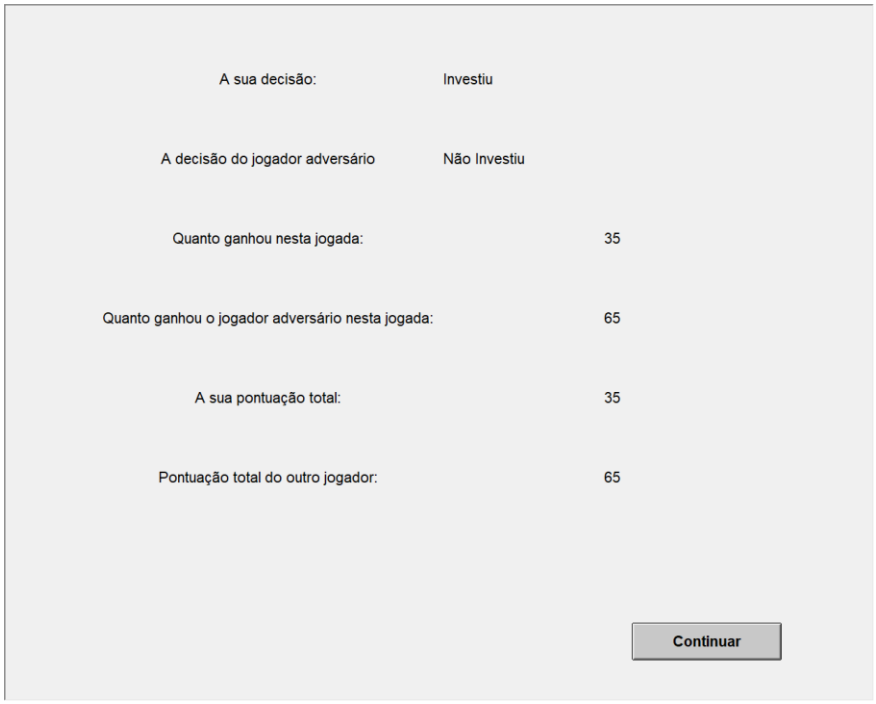
Note. Example of a DPD game in a time pressure within a loss frame condition.



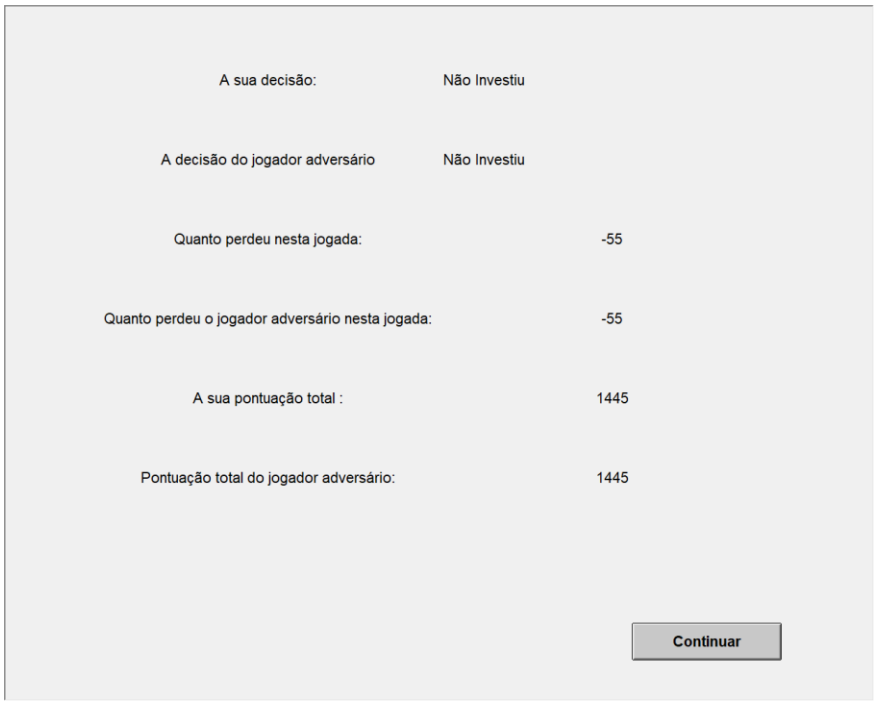
Note. Example of an SPD in a time delay within a gain frame condition. In the time delay condition, the buttons only appeared after 10 sec.



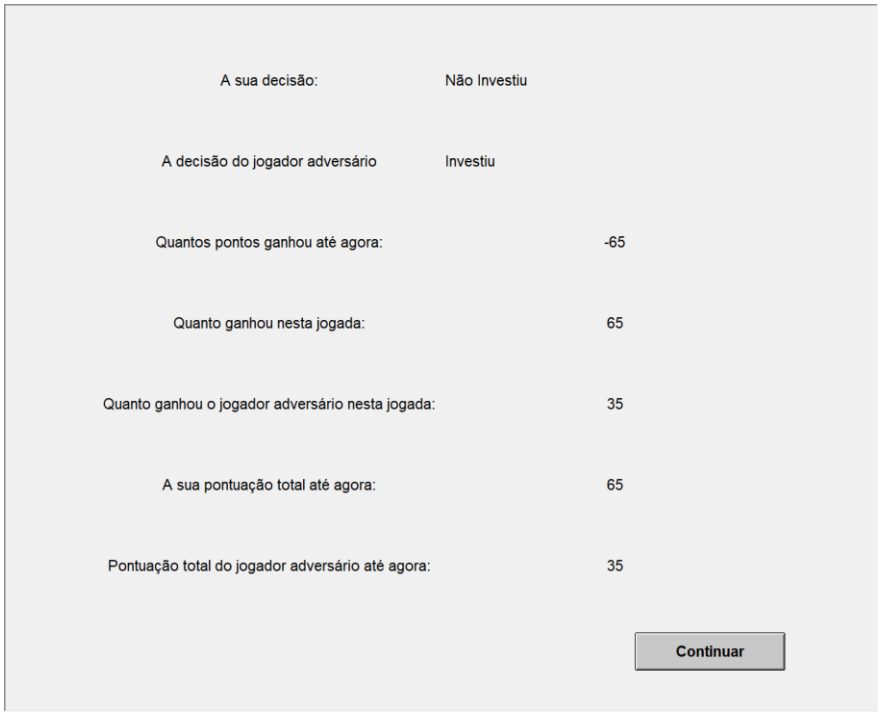
Note. Example of an SPD in a time pressure within a loss frame condition.



Note. Example of DPD feedback in a gain frame within a one-shot game.



Note. Example of DPD feedback in a loss frame within a one-shot game.



Note. Example of DPD feedback in a gain frame within a repeated game.

Appendix C: Supplementary Information of Study 3

C.1. Supplementary Results Study 3

Table C.1

Description of the Sociodemographic and COVID-19 Variables

Personal Characteristics	Level	*n* (%)
Gender	Men	122 (24.6)
	Women	374 (75.4)
Nationality	Portuguese	483 (97.4)
	Brazilian	10 (2.0)
	Venezuelan	1 (0.2)
	Sao Tomean	1 (0.2)
	Spanish	1 (0.2)
Highest academic qualification	6th Grade	2 (0.4)
	9th Grade	15 (3.0)
	12th Grade	290 (58.5)
	Bachelor of Arts/Science	106 (21.4)
	Master	77 (15.5)
	Postgraduate	2 (0.4)
	Doctorate	4 (0.7)
Socio-economic status	Low	14 (2.8)
	Medium-low	103 (20.8)
	Medium	324 (65.3)
	Medium-high	55 (11.1)
Employment status	Employed	161 (32.5)
	Student	262 (52.8)
	Working student	46 (9.3)
	Unemployed	15 (3.0)
	Did not reveal	12 (2.4)
COVID-19 work situation	Remote	309 (62.3)
	On-site	97 (16.4)
	Stay home without working	39 (6.6)
	B-learning	8 (1.3)
	Work in fortnightly periods	7 (1.2)
	Informal Caregiver	2 (0.3)
	Student Worker	30 (5.1)
	Did not answer	4 (0.7)
Doing quarantine or prophylactic isolation	Yes	213 (35,9)
	No	283 (47,7)
COVID-19 infection	Infected at the moment	2 (0,3)
	Already been infected	4 (0.7)
	Not being infected	485 (81.8)
	Do not know	5 (0.8)
Family/Friends COVID-19 infection	Had friends/family infected	35 (7.1)
	Have friends/family already been infected	76 (15.3)

	Not have friends/family infected	385 (77,6)

Note. Results are shown in absolute and relative (%) frequencies.

Table C.2

Confirmatory Factor Analysis for the COVID-19 Risk Perception Scale Items

Item number	Item	Perceived spread of COVID-19	Perceived impact of COVID-19	Perceived distant spread of COVID-19
1	How likely do you think you are to catch the virus	0.72		
2	How badly do you think you will be affected economically if you specifically catch the virus? (for example through loss of work)		0.48	
3	How likely do you think it is that a loved one will become infected?	0.88		
4	How likely do you think the average person in your state is to become infected?			0.99
5	How badly do you think your health will be affected if you do catch the virus?		0.70	
6	How badly do you think you will be affected by the global effects of the virus (for example economic recession, reduced healthcare capacity)?		0.43	
7	How likely do you think the average person in your neighbourhood is to become infected?	0.61		
8	How likely do you think the average person in your country is to become infected?			0.49
9	If you do contract the virus and pass it on to someone else, how badly do you think they would be affected?		0.63	

Figure C.1

Three-Factor Model of the COVID-19 Risk Perception Scale

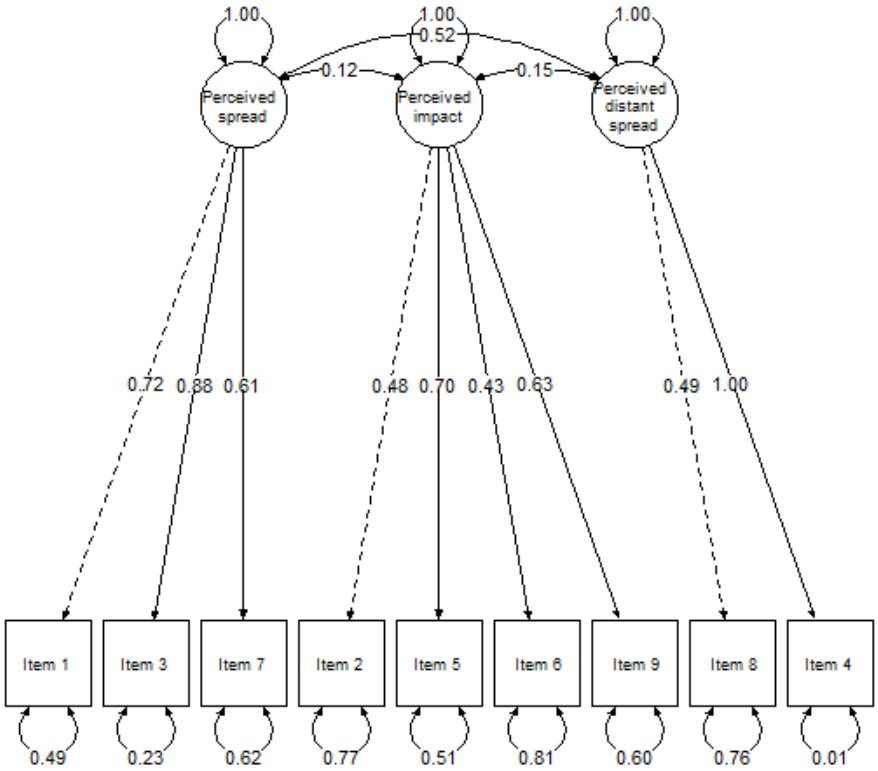


Table C.3

ANOVA and Kruskal-Wallis Tests for the Individual Difference's Variables

	χ^2	*F*	*p*
Probabilistic Discounting Task: AUC		0.27	.85
Subjective Covid-19 Risk Perception: Perceived Spread		0.56	.29
Subjective Covid-19 Risk Perception: Perceived Distant Spread		1.27	.29
Subjective Covid-19 Risk Perception: Perceived Impact		1.75	.16
IRI-Perspective Taking		0.80	.49
IRI-Empathic Concern		0.66	.58
IRI-Personal Distress		1.65	.18
IRI-Fantasy		0.98	.40
SVO	10.20		.18
Gender	9.95		.19
Age	0.54		.66
Socio-Economic Status	15.34		.03
Follow the recommendations of the general health direction	13.60		.06

Table C.4

Pairwise Post-Hoc Dunn Test With Bonferroni Adjustments

Comparison	Z	*p adj*
1 - 2	-0.70	1.00
1 - 3	-1.79	1.00
2 - 3	-1.04	1.00
1 - 4	-0.40	1.00
2 - 4	0.30	1.00
3 - 4	1.37	1.00
1 - 5	-2.44	.41
2 - 5	-1.78	1.00
3 - 5	-0.89	1.00
4 - 5	-2.08	.91
1 - 6	0.22	1.00
2 - 6	0.84	1.00
3 - 6	1.80	1.00
4 - 6	0.58	1.00
5 - 6	2.41	.41

1 - 7	-1.93	1.00
2 - 7	-1.26	1.00
3 - 7	-0.33	1.00
4 - 7	-1.55	1.00
5 - 7	0.52	1.00
6 - 7	-1.94	1.00
1 - 8	-2.44	.40
2 - 8	-1.78	1.00
3 - 8	-0.90	1.00
4 - 8	-2.07	.89
5 - 8	-0.02	.98
6 - 8	-2.41	.40
7 - 8	-0.53	1.00

Note. Results from the different conditions on the socioeconomic status.

Appendix D: Empirical Study 1 and 2 Ethical Approval

The Ethics Committee for Human and Social Sciences of the University of Minho (CEICSH 033/2019) has granted approval for Empirical Studies 1 and 2, presented in Chapter 2 and Chapter 3 of the current dissertation, as demonstrated below:



Universidade do Minho

Conselho de Ética

Comissão de Ética para a Investigação em Ciências Sociais e Humanas

Identificação do documento: CEICSH 033/2019

Relatores: Emanuel Pedro Viana Barbas de Albuquerque e Marlene Alexandra Veloso Matos

Título do projeto: *Como é que indivíduos cooperam em situações de incerteza*

Equipa de Investigação: Daniela Costa, Doutoramento em Psicologia Básica, Escola de Psicologia da Universidade do Minho; Professor Doutor José Keating, Professor Associado no Departamento de Psicologia Básica, Escola de Psicologia Universidade do Minho; Professora Doutora Joana Arantes, Investigadora Auxiliar, Centro de Investigação em Psicologia (CIPsi), Escola de Psicologia, Universidade do Minho

PARECER

A Comissão de Ética para a Investigação em Ciências Sociais e Humanas (CEICSH) analisou o processo relativo ao projeto de investigação acima identificado, intitulado *Como é que indivíduos cooperam em situações de incerteza.*
Os documentos apresentados revelam que o projeto obedece aos requisitos exigidos para as boas práticas na investigação com humanos, em conformidade com as normas nacionais e internacionais que regulam a investigação em Ciências Sociais e Humanas.
Face ao exposto, a Comissão de Ética para a Investigação em Ciências Sociais e Humanas (CEICSH) nada tem a opor à realização do projeto, emitindo o seu parecer favorável, que foi aprovado por unanimidade pelos seus membros.

Braga, 26 de junho de 2019.

O Presidente da CEICSH

Assinado por : **ACÍLIO DA SILVA ESTANQUEIRO ROCHA**
Num. de Identificação Civil: BI042754054
Data: 2019.07.05 14:45:54 Hora de Verão de GMT



Anexo: Formulário de identificação e caracterização do projeto

Appendix E: Empirical Study 3 Ethical Approval

The Ethics Committee for Human and Social Sciences of the University of Minho (CEICSH 43/2020) has granted approval for Empirical Study 3, presented in Chapter 4 of the current dissertation, as demonstrated below:



Universidade do Minho

Conselho de Ética

Comissão de Ética para a Investigação em Ciências Sociais e Humanas

Identificação do documento: CEICSH 43/2020

Relatores: Emanuel Pedro Viana Barbas Albuquerque e Marlene Alexandra Veloso Matos

Título do projeto: *Comportamentos prosociais numa situação de incerteza social*

Equipa de Investigação: Daniela Costa, Doutoramento em Psicologia Básica, Escola de Psicologia, Universidade do Minho; Professor Doutor José Keating e Professora Doutora Joana Arantes (Orientadores), Escola de Psicologia, Universidade do Minho

PARECER

A Comissão de Ética para a Investigação em Ciências Sociais e Humanas (CEICSH) analisou o processo relativo ao projeto de investigação acima identificado, intitulado *Comportamentos prosociais numa situação de incerteza social.*
Os documentos apresentados revelam que o projeto obedece aos requisitos exigidos para as boas práticas na investigação com humanos, em conformidade com as normas nacionais e internacionais que regulam a investigação em Ciências Sociais e Humanas.
Face ao exposto, a Comissão de Ética para a Investigação em Ciências Sociais e Humanas (CEICSH) nada tem a opor à realização do projeto, emitindo o seu parecer favorável, que foi aprovado por unanimidade pelos seus membros.

Braga, 26 de maio de 2020.

O Presidente da CEICSH

(Acílio Estanqueiro Rocha)

Anexo: Formulário de identificação e caracterização do projeto