Freedom, Power and Interference: An Experiment on Decision Rights*

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Abstract

We propose a theoretical foundation for preference for decision rights, driven by preference for freedom, power, and non-interference, which can lead subjects to value decision rights intrinsically, i.e., beyond the expected utility associated with them. We conduct a novel laboratory experiment in which the effect of each preference is distinguished. We find that the intrinsic value of decision rights is driven more strongly by preference for non-interference than by preference for freedom or power. This result suggests that individuals value decision rights not because of the actual decision-making process but rather because they dislike others interfering in their outcomes.

Keywords: decision rights, freedom, power, experiments.
JEL codes: C92, D03, D23, D82.

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1 Introduction

Freedom and power are pervasive components in any social, political, and economic interaction in our lives. In any organization, from clubs to corporations and government bodies, individuals interact by making decisions, affecting themselves to the extent that they have the freedom to do so, and affecting others to the extent that they have the power to do so. Thus, freedom and power are fundamentally related to the exercise of decision rights. Economics, which has traditionally considered decision rights solely for their instrumental value in achieving outcomes, has recently moved to consider decision rights also for their intrinsic value, i.e., the value beyond the expected utility associated with them. In doing so, economics has built on previous literature in philosophy and sociology that has highlighted the intrinsic value of freedom and power.[1]

In this paper, we propose a theoretical foundation for preference for decision rights, driven by preference for freedom, power, and non-interference, and we conduct a novel laboratory experiment in which the effect of each preference can be distinguished. We employ the following terminology. An agent experiences *freedom* when his actions influence his own outcomes. An agent experiences *power* when his actions influence another agent's outcomes. An agent does not experience *interference* (in other words, he experiences *non-interference*) when his outcomes are not influenced by another agent's actions. In addition to preferences over outcomes, which lead agents to value decision rights instrumentally, agents have preference for freedom, power, and non-interference, which can lead them to value decision rights intrinsically.

Consider the following situation as an example. On Tuesday, John and his siblings agree that they will watch a movie together at the cinema the following Sunday and that on Sunday John will choose the movie to watch. On Tuesday, it is already known that two movies will be available on Sunday: a drama and a comedy. What neither John nor any of his siblings knows on Tuesday is what movie they will each prefer on Sunday. Holding the decision right, John will be able to choose one movie or the other depending on his preferences. If his preferences change, so will the movie he chooses. According to our terminology, John has freedom since his preferences will determine which movie

[1] In philosophy, the view that "liberty" and wellbeing are strongly connected originates from Mill (1963). In sociology, McClelland (1975) views "power" as an intrinsic human need.

he watches. John also has power since his preferences will determine which movie his siblings watch. Finally, John experiences non-interference since his siblings' preferences will not influence which movie he watches. But what if only the comedy is available? Then, since John will necessarily watch the comedy, neither his preferences nor his siblings' preferences will determine which movie he watches. Thus, he does not have freedom, but he does experience non-interference. In addition, since his siblings will necessarily watch the comedy, John's preferences will not determine which movie his siblings watch: he does not have power. Finally, what if John's preferences are fixed such that he cannot prefer anything other than comedy? Then, even if he has the decision right, John has neither freedom nor power: he cannot choose one movie or the other depending on his preferences but he will necessarily watch the comedy as will his siblings.[2]

Contributions. We present a general theoretical model of decision-rights allocation and choice, which we formulate in the context of extensive form games. Within a Bayesian Nash equilibrium setting, the model can represent a player who may change his behavior at an earlier stage of the game in anticipation of greater freedom, power, and non-interference at a later stage. Specifically, in a setting where a player can bid for a decision right via an auction mechanism, his bid may be influenced by the freedom, power, and non-interference conveyed by the decision right. The model has several key features. First, since players may at a particular point in time not yet know their preferences over outcomes (e.g., John does not know on Tuesday whether he will prefer a drama or a comedy on Sunday), the information sets contain both nodes and preference profiles. Second, outcome functions associating each terminal node with an outcome are player-specific. This allows us to distinguish freedom, which involves influencing one's own outcomes, from power, which involves influencing other players'

[2] In our example, we mentioned how the holder of the decision right may loose freedom and power while maintaining non-interference. The question may arise, whether a decision right necessarily delivers non-interference to its holder. This is not the case. We can think of examples in which a decision right delivers power, but not non-interference, as well as situations in which a decision right delivers freedom, but not non-interference. In the first case, consider two individuals, i and j, each making a decision, such that i's decision affects j while j's decision affects i. Then both have power but neither experiences non-interference. In the second case, consider a decision being made not by a single individual but by a group of individuals sharing the decision right and employing a majority rule. Then each individual in the group experiences both partial freedom and partial interference.

outcomes. Third, the causal influence of preference profiles on outcomes is measured by how far the joint distribution of outcomes and preference profiles is from the independent case.

We then implement a simplified version of the model in our experiment. In the experiment, pairs of participants (Player 1 and Player 2) play a game that involves the allocation and the exercise of a decision right. First, Player 1 bids for the decision right. Second, if Player 1 receives the decision right, he exercises it; otherwise Player 2 exercises it. The exercise of the decision right consists of making a final choice, which generates payoff consequences for both players. Uncertainty regarding the payoff consequences is resolved before the final choice is made, but only after the bid for the decision right is submitted by Player 1. Across treatments and rounds, we vary the freedom, power, and non-interference associated with the decision right. We estimate how Player 1's preference for freedom, power, and non-interference affects his valuation of the decision right, as revealed by his bid. A higher bid has two effects. First, it increases the probability that Player 1 will hold the decision right. Second, it decreases the payoff uncertainty for Player 1. Therefore, it is crucial to distinguish between two different motivations for a high bid: intrinsic valuation of the decision right and risk aversion. By eliciting individual risk preferences in an additional game, we compare the actual bids with the bids implied by the elicited risk preferences.

Results and implications. Evidence from our experiment confirms the existence of an intrinsic value of decision rights, as previously reported in Fehr et al. (2013) and Bartling et al. (2014), and extends it from a delegation setting to a willingness-to-pay/auction setting. Most importantly, our theoretical framework and experimental design allow us to disentangle the drivers behind this phenomenon.

We highlight two main findings. First, we find no evidence of preference for power. This result suggests that preference for power, as casually observed in politics or other institutional settings, may simply be instrumental to other components of well-being, such as status recognition.

Second, we find stronger evidence of preference for non-interference than for freedom. This result suggests that individuals value decision rights not because of the actual decision-making process but because they have preference against others intervening in their outcomes. This result leads to a fundamental change in perspective on preference for decision rights. Individuals like to have decision rights in virtue of the absence of the decision rights of other individuals. An individual's evaluation of risks then depends on whether risks are generated by an objective process or by the behavior of other individuals.

Related literature. This paper lies at the intersection of several literatures, both experimental and theoretical. The paper builds on previous experimental work documenting the intrinsic value of decision rights. In a principal-agent experiment, Fehr et al. (2013) find that principals often decide not to delegate a decision right to an agent even when delegation would provide large expected utility gains. Bartling et al. (2014) report that two game-specific characteristics affect the intrinsic value of decision rights. The intrinsic value of decision rights is higher when the stake size and the alignment of interests between the principal and the agent are higher. They find that the intrinsic value of decision rights cannot be explained by risk preferences, social preferences, ambiguity aversion, loss aversion, illusion of control, preference reversal, reciprocity, or bounded rationality. Instead, they conclude that the intrinsic value of decision rights originates from an intrinsic preference for decision rights. Our paper tackles the unanswered question of what the ultimate drivers of a preference for decision rights are. In contrast to Fehr et al. (2013) and Bartling et al. (2014) we find no intrinsic value of having a decision right, but rather an intrinsic value of others not having the decision right.

Our paper builds on concepts and measures originally developed in the literature on freedom of choice (Barberà et al. 2004, Baujard 2007, Dowding and van Hees 2009) and the power index literature (Penrose 1946, Shapley and Shubik 1954, Banzhaf 1965, Diskin and Koppel 2010). The measures we propose for freedom and non-interference are closely related to the concepts of positive and negative freedom, originally introduced in philosophy by Berlin (1958), though not in the context of strategic interaction.

In addition to the literatures mentioned above, our work can contribute to diverse literatures that analyze attitudes toward decision rights and their effect on behavior in applied settings, such as the corporate governance literature on the allocation and exercise of control (Dyck and Zingales 2004) and the human resource management literature on workers' autonomy in the workplace (Handel and Levine 2004).

We highlight two concepts that are related to our main result (i.e., the intrinsic value of decision rights) but not to our framework: preference for flexibility (Kreps 1979) and betrayal aversion (Bohnet and Zeckhauser 2004). First, preference for flexibility does not apply to our framework, nor to Fehr et al. (2013) and Bartling et al. (2014), since preference for flexibility is already captured in the behavior predicted by the Nash equilibrium. In our experimental design, players learn about their preferences over outcomes after the decision right is assigned. In the Nash equilibrium, individuals anticipate at an earlier stage the value of being able at a later stage to make a final choice instead of receiving the outcome of a lottery. Thus, the value of flexibility is fully incorporated to the Nash equilibrium behavior. Our observed deviations from Nash equilibrium behavior cannot be explained by preference for flexibility.[3]

Second, Bohnet and Zeckhauser (2004) report experimental evidence suggesting that the decision not to trust another agent is driven by betrayal aversion. In their experimental design, the decision to trust someone (letting another agent make a final choice that has payoff consequences for both agents) entails an additional risk premium compared to the decision to let a random-device lottery determine the final choice and payoff consequences. They argue that the additional risk premium is required to balance the costs of trust betrayal.[4] However, as they acknowledge, their design cannot establish whether differences in behavior are due to different assessments of the outcomes, so they cannot rule out the possibility that their results are driven not by an aversion to betrayal but by an aversion to relinquishing control to another agent ("interference" in our framework).[5] Our results suggest that aversion to interference may be a driver

[3]In our movie example, preference for flexibility refers to the expected utility gain from the ability to choose the movie that one likes best. This is captured by Nash equilibrium behavior. Preference for freedom is the procedural rather than the consequentialist value of one's own preferences determining the outcomes.

[4]Bohnet and Zeckhauser (2004) compare behavior in a trust game and a risky dictator game. The trust game involves a binary choice by Player 1 (to trust or not to trust) followed by a binary choice by Player 2 conditional on Player 1's decision to trust. The risky dictator game differs only in that Player 1's decision to trust is followed by a random-device lottery, not by a choice by Player 2. In both games, a decision not to trust yields payoffs (S,S) to Player 1 and 2, respectively. Following a decision to trust, the payoff pairs can be either (B,C) or (G,H), with $G > S > B$ and $C > H > S$. In both games, participants with the role of Player 1 report their minimum acceptable probability (MAP) of getting G such that they prefer to trust instead of not to trust.

[5]"A MAP gives us information on how a Decision Maker assesses the risky-choice problem

of behavior in their experiment.

Plan of the paper. The paper proceeds as follows. In Section 2, we outline a behavioral model of preference for freedom, power, and non-interference. Section 3 describes the experimental design. We present the theoretical predictions of the model in Section 4 and the empirical strategy in Section 5. The results are given in Section 6. Section 7 concludes.

2 Theoretical framework

In this section, we describe a model of decision-rights allocation and choice. To provide a general theoretical framework, we formulate the model in the context of extensive form games. We then implement a simplified version of the model in our experiment.

Consider an extensive-form game $\eth = (N, A, \psi, \mathscr{P}, \mathscr{I}, \mathscr{C}, O, \mathscr{U}, p)$. $N = \{1, \ldots, n\}$ is a finite set of players, and A is a finite set of nodes. $\psi : A/a_0 \to A$ is a predecessor function such that, for node a, $\psi(a)$ is the immediate predecessor of a. $\mathscr{P}$ is the player partitioning of the nodes. $\mathscr{I} = \{I_0, \ldots, I_n\}$ is the information partitioning, with I_i being the set of information sets of Player i, and $A(I) = \{a \in A : \psi(a) \in I\}$ is the set of nodes following information set I. $\mathscr{C}$ is the set of choice sets C_I for each information set I, and $\Delta(C_I)$ is the set of probability distributions over the choice set at I. For $b \in I$ and $b = \psi(a)$, let $c(a|b) \in C_I$ be the choice that leads from node b to node a.

Our notation diverges from the standard notation of game forms in two main respects. First, $O = \{o_1, ..., o_n\}$ is the set of outcome functions, where $o_i : A_\omega \to O_i$ maps the terminal nodes $A_\omega = A \backslash \psi(A)$ into the finite set of possible outcomes for Player i, O_i. We require player-specific outcome functions to distinguish power from freedom. Having power means being able to influence another player's outcomes. Having freedom means being able to influence one's own outcomes. Outcome functions that are not player-specific would conflate power and freedom.

Second, $\mathscr{U} = \{U_1, \ldots, U_n\}$ is the set of sets of utility functions $U_i = \{u_i^1, \ldots, u_i^J\}$

he is confronted with, but not on how he values each possible outcome. Based on our data, we are not able to distinguish whether differences in MAPs are due to different assessments of S or of B and G."

for each Player i, where $u_i^j : O_i \to \mathbb{R}$. Since freedom requires the possibility to act in one way or another, individuals need to potentially have more than one preference profile to have freedom. Since individuals may at a particular point in time not yet know their preferences, information sets contain both nodes and utility functions: $I \subseteq A \cup_{i \in N} U_i$ such that $I \cap A \neq \emptyset$ and $\forall i : I \cap U_i \neq \emptyset$. For example, at an information set $I \in I_1 = \{a_1, a_2, u_1^1, u_1^2, u_2^1\}$, Player 1 does not know whether he is at node a_1 or a_2 and whether he has preferences u_1^1 or u_1^2, but he knows that Player 2 has preferences u_2^1.

A local strategy $s_I \in \Delta(C_I)$ is a probability distribution over the elements of the choice set at information set I. A strategy profile S is a tuple of local strategies specifying behavior at each information set $S = (s_I|_{I \in I_i}|_{i \in N})$. p is the probability distribution for moves by Nature at information sets in $\mathscr{I}_0$ and over utility functions for each player. Finally, θ^S denotes the joint probability distribution over nodes, outcomes, and preference profiles resulting from strategy profile S and moves by Nature according to p. The subgame function $subg(\Game, a)$ returns for any game $\Game$ the subgame starting at node a. Let θ_i be a joint probability distribution over nodes, outcomes, and preference profiles representing the beliefs of Player i. Let $\theta_{i|I}$ ($\theta_{i|a}$) denote the beliefs of Player i given that play has reached information set I (node a), derived from Bayesian updating on θ_i. We can construct the belief of node a following the current information set given strategy s_I as $\tilde{\theta}_{i|s_I}(a) = \theta_{i|I}(\psi(a)) \cdot s_I(c(a|\psi(a)))$.

Finally, we define an equilibrium of game $\Game$ as a strategy profile $S^* = (s^*(I, \theta_i)|_{I \in I_i}|_{i \in N})$ and beliefs such that $\forall i : \theta_i = \theta^{S^*}$ with:

$$s^*(I, \theta_i) = \arg \max_{s \in \Delta(C_I)} \sum_{a \in A(I)} \tilde{\theta}_{i|s}(a) V_i(subg(\Game, a), \theta_{i|a}). \tag{1}$$

This definition corresponds to a standard Bayesian Nash equilibrium if $V_i(\Game, \theta)$ coincides with expected utility $EU_i(\Game, \theta)$:

$$EU_i(\Game, \theta) = \sum_{u \in U_i} \theta(u) \sum_{o \in O_i} \theta(o|u) u(o). \tag{2}$$

Instead, we define V_i to include also the utility from freedom, power, and non-interference for each subgame. Thus, individuals may change their behavior at earlier stages of the game in anticipation of greater freedom, power, and non-interference at later stages. Note that, in this framework, there are two distinct notions of preferences. First, there are the non-procedural preferences over outcomes, $u \in U_i$. Second, there are the procedural preferences over subgames, V_i, containing a player's preference for freedom, non-interference, and power. To avoid confusion, we refer to the former in the plural and the latter in the singular. We use the following terminology.

Freedom. Player i has *freedom* if he causally influences his own outcomes. In our movie example, John has freedom if his preferences on Sunday determine which movie he watches. Thus, freedom is measured by the degree to which Player i's own preferences determine his own outcomes, as

$$\Phi_i^f(\eth, \theta) = \sum_{u \in U_i} \theta(u) \sum_{o \in O_i} g(o,u)\theta(o|u) \log_2 \frac{\theta(o|u)}{\theta(o)}, \tag{3}$$

where $\log_2 \frac{\theta(o|u)}{\theta(o)}$ is the causal influence measure capturing how far the joint probability of outcome o and preference profile u is from the independent case. The measure computes the expectation of these terms across all preference-outcome combinations. For example, take two outcomes A and B and an individual who prefers either A or B; i.e., he has preference profile u^A or u^B. If $\theta(A|u^A) = \theta(A) = 1 - \theta(B)$, the fact that an individual prefers A or B makes no difference on whether the outcome is A or B. This is captured by the causal influence measure via $\log_2 \frac{\theta(o|u)}{\theta(o)} = 0$ for all $o \in \{A, B\}$ and $u \in \{u^A, u^B\}$. However, if the individual has some influence, then $\theta(A|u^A) > \theta(A)$, and this will result in a positive causal influence measure. This measure captures Berlin's definition of positive freedom as "[t]he freedom which consists in being one's own master" (1958, p.8) and other concepts from the literature on freedom of choice.[6]

The function $g(o,u)$ is included to capture the value of the causal influence. For example, if two outcomes are qualitatively very similar, the value of having the freedom to choose between the two may be very low. If in the cinema only one movie is playing and the only choice to make is whether to watch it in theater 1 or 2, the alternative outcomes may not be qualitatively distinct enough for the decision right to provide a high amount of freedom. The causal influence

[6]For details, see Rommeswinkel (2014).

measure $\log_2 \frac{\theta(o|u)}{\theta(o)}$ between outcome o and preferences u is therefore weighted by $g(o,u)$. Several specifications of $g(o,u)$ will be discussed in Section 4.

Non-Interference. Player i has *non-interference* if other players do not causally influence his outcomes. In our movie example, John experiences non-interference if he chooses the movie or if only one movie is available. In both cases, others' preferences do not influence which movie he watches. Interference is measured by the degree to which other players' preferences determine Player i's own outcomes. Thus, non-interference is measured by

$$\Phi_i^{ni}(\partial, \theta) = -\sum_{j \in N \setminus i} \sum_{v \in U_j} \theta(v) \sum_{u \in U_i} \theta(u|v) \sum_{o \in O_i} g(o,u)\theta(o|v) \log_2 \frac{\theta(o|v)}{\theta(o)}. \quad (4)$$

The concept of non-interference is analogous to that of freedom. The difference is that non-interference captures not the causal influence that a player has on his own outcomes but the causal influence that other players have on his outcome. This measure is closely related to Berlin's definition of negative freedom as "not being interfered with by others. The wider the area of non-interference, the wider my freedom"(1958, p.3). Again, $g(o,u)$ can be used to determine the value of not being interfered with. For example, interference may matter little to John if his siblings only get to choose whether to watch the movie in theater 1 or 2 but do not choose the movie itself. Reducing the interference of another player may be less valuable when its qualitative impact on the outcome is small compared to the case in which it is large.

Power. Player i has *power* if he causally influences the outcomes of other players. In our movie example, if John chooses the movie, then John has power since his preferences determine which movie his siblings watch. However, if only one movie is available at the cinema, John does not have power since his preferences do not determine which movie his siblings watch: they simply watch the only available movie. Power is measured as

$$\Phi_i^{p}(\partial, \theta) = \sum_{u \in U_i} \theta(u) \sum_{j \in N / i} \sum_{o \in O_j} g(o,u)\theta(o|u) \log_2 \frac{\theta(o|u)}{\theta(o)}. \quad (5)$$

This measure is similar to the voting power measure by Diskin and Koppel

(2010), with the exceptions that we introduced player-specific outcomes and a weighting function $g(o,u)$, and generalized the measure to extensive form games. The weighting function $g(o,u)$ measures the qualitative impact on the outcomes of those players over whom Player i has power.

The valuation function $V_i(\Game,\theta)$ of a Player i with preference for freedom, non-interference, and power includes all the above components, as

$$V_i(\Game,\theta) = \alpha_i\Phi_i^f(\Game,\theta) + \beta_i\Phi_i^{ni}(\Game,\theta) + \gamma_i\Phi_i^p(\Game,\theta) + \delta_i EU_i(\Game,\theta), \qquad (6)$$

where coefficients α, β, γ, and δ determine the intensity of each component. An individual with preference for freedom/non-interference/power evaluates the choices not only by the expected utility of the subgame following the choice but also by the expected freedom/non-interference/power offered by the subgame. In Appendix B, as an illustration, we apply our theoretical framework to the authority game of Fehr et al. (2013).

2.1 Discussion

Measuring freedom, non-interference, and power requires determining not only what individuals can causally influence (i.e., their own or others' outcomes) but also what enables individuals to exercise such a causal influence (i.e., the source of agency). Agency is what allows an individual to behave in one way or another and to achieve one outcome or another by doing so. Outside of an experimental setting, the source of agency lies in an individual's preferences over the alternative outcomes. In an experimental setting, it is standard practice to induce the value of each alternative via monetary payments.[7] Thus, the source of agency is introduced by the game structure by means of a payment structure. This is unproblematic in experiments that investigate how behavior changes if the values of the alternatives change: manipulating the monetary payments is sufficient. However, an experiment such as ours, which investigates how behavior changes if freedom/non-interference/power change, requires making the formation of preferences part of the game since manipulating freedom/non-interference/power requires manipulation of the relationship be-

[7] For an introduction to induced-value theory, see Smith (1976).

tween preferences over outcomes and outcomes. We achieve this by having preferences over outcomes randomly determined by moves of Nature at the beginning of a subgame.

While we are aware that freedom in real-world situations may be qualitatively different from freedom induced by the game structure, we also believe that our framework makes preference for freedom more unlikely to be observed in the experiment. Therefore, evidence of preference for freedom in the experiment suggests that such preference for freedom is even more likely to arise in real-world settings, where preferences are not induced but formed internally. Analogous arguments can be made for preference for non-interference and for power.

3 Experimental design

The experiment implements a simplified version of the theoretical framework presented in Section 2. Two players, Player 1 and Player 2, play a game involving the selection of a card from one of two boxes, Box L and Box R. Box L and Box R each contain two cards, Card A and Card B. Each card has two sides, Side 1 and Side 2.

The game consists of two stages: a bidding stage and a choice stage. The bidding stage serves to determine which player has the decision right in the choice stage. In the choice stage, the player with the decision right makes the card selection. The decision right is allocated via a Becker-DeGroot-Marschak (BDM) mechanism (Becker et al. 1964). Player 1 is required to bid for the decision right by choosing an integer between 0 and 100, $y \in \{0, \ldots, 100\}$. The computer then randomly determines an integer between 1 and 100 with uniform probability, $r \in \{1, \ldots, 100\}$. If $y \geq r$, Player 1 has the decision right: he will select a card from Box L in the choice stage and pay a fee equal to r. Otherwise, Player 2 has the decision right: he will select a card from Box R in the choice stage, and no fee is paid by either player.

In each box independently, the colors of the sides of the cards are determined via a random draw from the four cases represented in Figure 1. Each case has a priori equal probability. The color of Side 1 is payoff-relevant for Player 1, and the color of Side 2 is payoff-relevant for Player 2. Green is associated with a higher payoff; i.e., $\pi_i^{high,K} > \pi_i^{low,K}$, where $\pi_i^{high,K}$ denotes Player i's payoff if Side i of the card selected from box K is green, and $\pi_i^{low,K}$ denotes Player i's payoff if Side i of the card selected from box K is red, and $K \in \{L,R\}$. Each side of each card can be green or red with equal probability. Moreover, Side i of Card A and Side i of Card B are always a different color, which guarantees that Player i prefers either Card A to be selected or Card B to be selected. If Side 1 and Side 2 of a given card are the same color, then the players prefer the same card. Otherwise, the players prefer different cards.[8] We can interpret the random draw from the four cases in Figure 1 as a move by Nature, which randomly determines players' preferences over outcomes, $U_1 \in \{u_1^A, u_1^B\}$ and $U_2 \in \{u_2^A, u_2^B\}$, as discussed in Section 2.

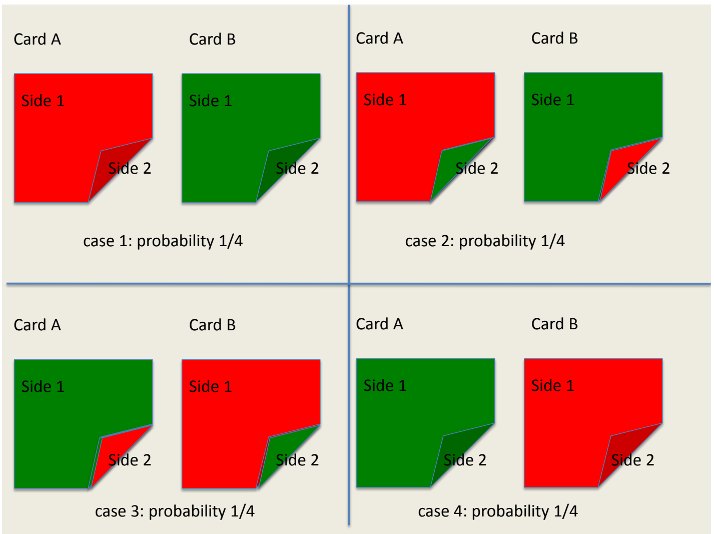

Figure 1: Card colors in Box $K = L,R$

The order of events is shown in Figure 2. As the bidding stage starts, players learn the values of $\pi_i^{high,K}$ and $\pi_i^{low,K}$ for $i = 1,2$ and $K \in \{L,R\}$. Thus, they learn, for each player and for each box, what the payoff associated with green and the payoff associated with red are. At this moment, neither player knows, for either box, whether he prefers Card A or B, or whether the other player prefers Card A or B. As the choice stage starts, players receive additional information. The box from which the card selection will occur is opened, and each player observes the colors on his side of the two cards: Player 1 observes

[8]As shown in Figure 1, in case 1, both players prefer Card B; in case 2, Player 1 prefers Card B and Player 2 prefers Card A; in case 3, Player 1 prefers Card A and Player 2 prefers Card B; in case 4, both players prefer Card A.

Side 1 of Card A and Side 1 of Card B, and Player 2 observes Side 2 of Card A and Side 2 of Card B. Therefore, each player learns which card gives him the higher payoff, i.e., which card he prefers. However, no player observes the colors on the other side of the two cards. Therefore, no player learns which card the other player prefers.

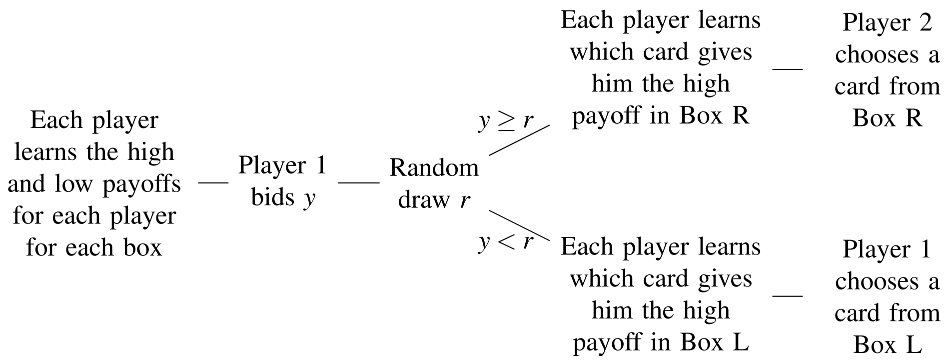

Figure 2: Order of events

To represent preference for freedom, non-interference, and power we must define the set of outcomes. For Player 1, let $O_1 = \{0, \ldots, 100\} \times \{1,2\} \times \{A,B\}$, with $o_1(r,i,c)$ denoting the outcome where the randomly drawn number is r and Player i has the decision right and chooses card c. For Player 2, the number r is never relevant, so let $O_2 = \{1,2\} \times \{A,B\}$, with $o_2(i,c)$ denoting the outcome where Player i has the decision right and chooses card c.

The payoff structure of the game is always common knowledge. Payoffs vary across rounds and treatments, as described in detail in Sections 3.1-3.2. Table 1 provides the general payoff structure. Player 1's payoff is $\pi_1(o_1(r,i,c), u_1^A)$ if he prefers Card A and $\pi_1(o_1(r,i,c), u_1^B)$ if he prefers Card B. Analogously, Player 2's payoff is $\pi_2(o_2(i,c), u_2^A)$ if he prefers Card A and $\pi_2(o_2(i,c), u_2^B)$ if he prefers Card B. Moreover, Player 1 and Player 2 start the game holding endowments w_1 and w_2, respectively.

3.1 Rounds

The game is played repeatedly for 20 rounds. Across rounds, we vary the values for Player 2's payoffs $\pi_2^{high,L}$ and $\pi_2^{low,L}$ to account for situations in which the

	$i=1$		$i=2$	
	$c=A$	$c=B$	$c=A$	$c=B$
$\pi_1(o_1(r,i,c),u_1^A)$	$w_1+\pi_1^{high,L}-r$	$w_1+\pi_1^{low,L}-r$	$w_1+\pi_1^{high,R}$	$w_1+\pi_1^{low,R}$
$\pi_1(o_1(r,i,c),u_1^B)$	$w_1+\pi_1^{low,L}-r$	$w_1+\pi_1^{high,L}-r$	$w_1+\pi_1^{low,R}$	$w_1+\pi_1^{high,R}$
$\pi_2(o_1(i,c),u_2^A)$	$w_2+\pi_2^{high,L}$	$w_2+\pi_2^{low,L}$	$w_2+\pi_2^{high,R}$	$w_2+\pi_2^{low,R}$
$\pi_2(o_1(i,c),u_2^B)$	$w_2+\pi_2^{low,L}$	$w_2+\pi_2^{high,L}$	$w_2+\pi_2^{low,R}$	$w_2+\pi_2^{high,R}$

Table 1: Payoff structure

decision right gives Player 1 power or does not. $\Game^{np}$ are games where $\pi_2^{high,L} = \pi_2^{low,L}$. Therefore, when Player 1 has the decision right and selects a card from Box L, he does not have power since he cannot influence Player 2's outcomes: Player 2 is indifferent between the cards since $\pi_2^{high,L} = \pi_2^{low,L}$. $\Game^{p}$ are games where $\pi_2^{high,L} > \pi_2^{low,L}$, so the decision right gives Player 1 power. Across the 20 rounds, participants play 10 $\Game^{np}$ games and 10 $\Game^{p}$ games. Within $\Game^{np}$ and $\Game^{p}$, the rounds differ in the expected payoff and the stake size for each player, as shown in Table 2. The order in which the rounds are played is randomized. Note that, in both $\Game^{np}$ and $\Game^{p}$, we have $\pi_2^{high,R} > \pi_2^{low,R}$: Player 2 is never indifferent between the cards when he has the decision right. Finally, Player 1's payoffs are $\pi_1^{high,L} = \pi_1^{high,R} = \pi_1^{high}$ and $\pi_1^{low,L} = \pi_1^{low,R} = \pi_1^{low}$.

3.2 Treatments

We conducted the experiment under three treatments, in which we modified key features of the game. Games are denoted $\Game_1$, $\Game_2$, and $\Game_3$ in Treatment 1, 2, and 3, respectively. In the benchmark Treatment 1, both players received an endowment ($w_1 = w_2 = 100$). In Treatment 2, only Player 1 received an endowment ($w_1 = 100$, $w_2 = 0$). The variation in endowments allows us to verify whether social preferences play a role. Specifically, Player 1 may prefer to bid higher or lower due to advantageous or disadvantageous inequality aversion. We explore the role of inequality aversion in Appendix D.

In Treatment 3, $w_1 = 100$ and $w_2 = 0$, as in Treatment 2, but Box L contains only one card (Card C), which is green on Side 1 and is either red or green on Side 2. Under this modified design, the decision right provides Player 1 non-interference but neither freedom nor power. Similarly to the other treatments, if Player 1 has the decision right, he enjoys non-interference since Player 2 cannot influence Player 1's outcomes. However, Player 1 does not have freedom since

game	round	Box L Player 1 Green/Red π_1^{high}/π_1^{low}	Box L Player 2 Green/Red $\pi_2^{high,L}/\pi_2^{low,L}$	Box R Player 1 Green/Red π_1^{high}/π_1^{low}	Box R Player 2 Green/Red $\pi_2^{high,R}/\pi_2^{low,R}$
$\Game^{np}$	1	100/30	70/70	100/30	100/30
$\Game^{np}$	2	90/40	70/70	90/40	90/40
$\Game^{np}$	3	80/50	70/70	80/50	80/50
$\Game^{np}$	4	85/15	70/70	85/15	85/15
$\Game^{np}$	5	75/25	70/70	75/25	75/25
$\Game^{np}$	6	65/35	70/70	65/35	65/35
$\Game^{np}$	7	70/0	70/70	70/0	70/0
$\Game^{np}$	8	60/10	70/70	60/10	60/10
$\Game^{np}$	9	50/20	70/70	50/20	50/20
$\Game^{np}$	10	100/0	70/70	100/0	100/0
$\Game^{p}$	11	75/25	85/15	75/25	85/15
$\Game^{p}$	12	75/25	75/25	75/25	75/25
$\Game^{p}$	13	75/25	65/35	75/25	65/35
$\Game^{p}$	14	75/25	90/40	75/25	90/40
$\Game^{p}$	15	75/25	60/10	75/25	60/10
$\Game^{p}$	16	85/15	75/25	85/15	75/25
$\Game^{p}$	17	65/35	75/25	65/35	75/25
$\Game^{p}$	18	90/40	75/25	90/40	75/25
$\Game^{p}$	19	60/10	75/25	60/10	75/25
$\Game^{p}$	20	100/0	100/0	100/0	100/0

Table 2: Payoffs in each round

Treatment	Endowments w_1, w_2	Cards in Box L	Games	decision right gives Player 1: freedom	non-interference	power
1	100,100	A,B	$\Game_1^{np}$	*yes*	*yes*	*no*
			$\Game_1^{p}$	*yes*	*yes*	*yes*
2	100,0	A,B	$\Game_2^{np}$	*yes*	*yes*	*no*
			$\Game_2^{p}$	*yes*	*yes*	*yes*
3	100,0	C	$\Game_3$	*no*	*yes*	*no*

Table 3: Treatments

he cannot influence his own outcomes: there is no choice for him to make, since Box L contains only Card C. Moreover, Player 1 has no power since he cannot influence Player 2's outcomes. Treatment 3 allows us to distinguish non-interference from freedom, which are not distinguishable in Treatment 1 and 2.

Table 3 summarizes the characteristics of each treatment. Note that the distinction between games $\Game^{np}$ and games $\Game^{p}$ is relevant for Treatment 1 and 2, but not for Treatment 3, which does not involve power.

3.3 Procedures

We conducted eight sessions: three sessions of Treatment 1, three sessions of Treatment 2, and two sessions of Treatment 3. The sessions took place over two consecutive days in October 2013 at the Cologne Laboratory for Economic Research (CLER). Each session lasted approximately 1.5 hours. In total, 244 subjects participated: 86 in Treatment 1, 96 in Treatment 2, and 62 in Treatment 3.[9] Participants were recruited via ORSEE (Greiner 2004) and consisted mostly of students at the University of Cologne. The experiment was implemented in zTree (Fischbacher 1999). The experiment was divided into three parts. Participants received instructions for each part only after completing the previous part. The instructions are reported in Appendix E.

In Part 1, subjects played the card game described above.[10] At the start, half of the subjects were randomly assigned the role of Player 1 and the other half of the subjects the role of Player 2. Each Player 1 was randomly matched with a Player 2. The roles and the matches were then fixed for the entire duration of Part 1. Subjects played a trial round of game $\Game^{np}$ (which did not count for their earnings) and then played 20 rounds (10 games $\Game^{np}$ and 10 games $\Game^{p}$). Rounds were played in random order, and feedback regarding each round was given only at the end of the experiment (i.e., end of Part 3). At the end of the experiment, one round was randomly selected, and each subject was paid according to the payoff earned in that round only.

Part 2 and Part 3 involved individual decisions, with no interaction among subjects. In Part 2, subjects answered a lottery-choice questionnaire similar to that of Holt and Laury (2002). The lottery-choice questionnaire allows us to elicit subjects' risk attitudes. Each question involves the choice between a

[9] One session had 22 participants, one session 30 participants, and six sessions 32 participants.

[10] As Part 1 started, subjects received written instructions. To have participants focus on the key features of the game, we presented them with four comprehension questions. The questions are reported in Appendix E. When participants submitted an incorrect answer, they were provided with a correction and a short explanation. In general, subjects understood the experiment well. Questions 1, 2, and 3 were answered correctly by 96, 98, and 97 percent of the subjects, respectively. Question 4 was presented to highlight the fact that, if Player 1's bid was successful, Player 1 had to pay not his own bid but the number randomly drawn by the computer. Question 4, which is clearly the most difficult question, was answered correctly by 58 percent of the subjects. Individuals were thereby reminded, in a non-technical way, of the second-price nature of the bidding mechanism. Despite the lower fraction of initial correct answers, we believe that the provided correction and explanation were instrumental in achieving subjects' understanding.

safe lottery (Option A) that yields prize π^A with certainty and a risky lottery (Option B) yielding a high prize $\pi^{B,high}$ with probability 0.5 and a low prize $\pi^{B,low}$ with probability 0.5. The lotteries of Part 2 were designed to resemble the implicit lotteries faced by the players in the games of Part 1. Prize π^A resembles the certain payoff that a player receives when he has the decision right, while prizes $\pi^{B,high}$ and $\pi^{B,low}$ resemble the payoffs that a player may receive when the other player has the decision right. As discussed in Section 4, an expected-utility-maximizer Player 1 who chooses bid y^* in a game of Part 1 should choose the safe Option A in the corresponding lottery-choice question of Part 2 (with $\pi^{B,high} = \pi_1^{high}$, $\pi^{B,low} = \pi_1^{low}$) if and only if $\pi^A \geq \pi^{B,high} - y^*$. The questionnaire consists of 3 sets of 11 questions each. π^A is varied within each set, taking values from 30 to 80 in steps of 5 points. $(\pi^{B,high}, \pi^{B,low})$ are varied across sets. In the first set $(\pi^{B,high}, \pi^{B,low}) = (85, 15)$, in the second set $(\pi^{B,high}, \pi^{B,low}) = (75, 25)$, and in the third set $(\pi^{B,high}, \pi^{B,low}) = (65, 35)$. At the end of the experiment, one lottery-choice question was randomly selected. Each subject had his chosen option played out and was paid accordingly.

Finally, in Part 3, subjects completed a Locus of Control Test (Rotter 1966, Levenson 1981, Krampen 1981).[11] In personality psychology, locus of control refers to the extent to which individuals believe that they can control events that affect them. A person's locus is either internal (if he believes that events in his life derive primarily from his own actions) or external (if he believes that events in his life derive primarily from external factors, such as chance and other people's actions, which he cannot influence). There may be several reasons that attitudes toward locus of control may be related to attitudes toward freedom and non-interference. For example, subjects who believe that other individuals control their lives may have a greater preference for freedom and non-interference. However, as reported in Appendix C, we do not find strong evidence that attitudes toward locus of control are correlated with preference for freedom or non-interference.

At the end of the experiment, participants answered a socio-demographic questionnaire. All payoffs in the experiment were expressed in points. The conversion rate was €1 = 12 points. Individuals earned, on average, €10.97 in Part 1 and €4.90 in Part 2. In addition, subjects received €2.50 for participation.

[11] The questionnaire is reported in Appendix C.

4 Theoretical Predictions

The Bayesian Nash equilibrium predictions, assuming $V_i(\text{ᘐ}, \theta) = EU_i(\text{ᘐ}, \theta)$ and a utility function u linear in payoffs, are straightforward. In the choice stage, Player i with the decision right chooses $c^{*RNNE} = A \Leftrightarrow U_i = u_i^A$ and $c^{*RNNE} = B \Leftrightarrow U_i = u_i^B$. In the bidding stage, it is optimal for Player 1 to bid his true valuation of the decision right. The continuation payoff from the subgame where Player 1 has the decision right is π_1^{high}, and the continuation payoff from the subgame where he does not have the decision right is $(\pi_1^{high} + \pi_1^{low})/2$. Therefore, the optimal bid of a risk-neutral Player 1 is $y^{*RNNE} = (\pi_1^{high} - \pi_1^{low})/2$.

Allowing for risk aversion, while keeping $V_i(\text{ᘐ}, \theta) = EU_i(\text{ᘐ}, \theta)$, does not affect behavior in the choice stage: Player i with the decision right chooses $c^{*NE} = A \Leftrightarrow U_i = u_i^A$ and $c^{*NE} = B \Leftrightarrow U_i = u_i^B$. However, in the bidding stage, Player 1 is influenced by the fact that Box R involves the risky lottery $(\frac{1}{2}, \pi_1^{high}; \frac{1}{2}, \pi_1^{low})$ while Box L involves the safe lottery $(1, \pi_1^{high})$.[12] Therefore, the optimal bid y^{*NE} satisfies the following condition:

$$u(w_1 - y^{*NE} + \pi_1^{high}) = \frac{1}{2}u(w_1 + \pi_1^{high}) + \frac{1}{2}u(w_1 + \pi_1^{low}). \tag{7}$$

Defining the certainty equivalent CE of the risky lottery as

$$CE\left(\frac{1}{2}, \pi_1^{high}; \frac{1}{2}, \pi_1^{low}\right) = c : u(c) = \frac{1}{2}u(\pi_1^{high}) + \frac{1}{2}u(\pi_1^{low}), \tag{8}$$

we can rewrite Equation 7 in terms of certainty equivalent as

$$w_1 - y^{*NE} + \pi_1^{high} = CE\left(\frac{1}{2}, w_1 + \pi_1^{high}; \frac{1}{2}, w_1 + \pi_1^{low}\right). \tag{9}$$

To predict the behavior of a participant with preference for freedom, non-interference, and power, we need to determine freedom, non-interference, and power at each subgame following the bid of Player 1: the measures Φ_1^f, Φ_1^{ni}, and Φ_1^p introduced in Section 2. Before doing so, we must determine the functional form of $g(o,u)$ in Equations 3-5.

We consider two specifications. First and most simply, we can set $g(o,u) = 1$, assuming that the value of freedom, non-interference, or power is indepen-

[12] $(\frac{1}{2}, \pi_1^{high}; \frac{1}{2}, \pi_1^{low})$ is the lottery yielding π_1^{high} with probability 0.5 and π_1^{low} with probability 0.5. $(1, \pi_1^{high})$ is the lottery yielding π_1^{high} with probability 1.

dent of the outcome and the utility of the outcome. According to this first specification, we index the measures as $\Phi_1^{f,c}$, $\Phi_1^{ni,c}$, and $\Phi_1^{p,c}$. Second, we can set $g(o,u) = \Delta\pi_i = |\pi_i^{high} - \pi_i^{low}|$. While the logarithmic terms in Equations 3-5 account for the probabilistic causal influence of preferences on outcomes, the distance in payoffs $\Delta\pi_i$ measures the qualitative effect of such causal influence. For example, the decision between two outcomes yielding very similar payoffs may be seen as having a smaller qualitative effect than a decision between two outcomes yielding very different payoffs. Thus, freedom, non-interference, and power may become more important, as the alternative outcomes differ more in terms of the payoffs they yield. We must use $\Delta\pi_1$, the qualitative impact on Player 1's payoffs, for freedom and non-interference, and $\Delta\pi_2$, the qualitative impact on Player 2's payoffs, for power. According to this second specification, we index the measures as $\Phi_1^{f,d}$, $\Phi_1^{ni,d}$, and $\Phi_1^{p,d}$.[13]

Decisions in the choice stage are unaffected by preference for freedom, non-interference, and power. Since the subgame following each choice is a terminal node a_ω, we have $\theta(o(a_\omega)) = 1$, so the causal influence measures $\log_2 \frac{\theta(o|u)}{\theta(o)}$ are equal to zero. This is intuitive: while the individual has control over the outcome at the moment of making the decision, he loses the control by exercising it. Since the terminal nodes do not offer any freedom, non-interference, or power, the choice over terminal nodes is therefore unaffected by preference for them. Thus, an individual i with $\delta_i > 0$ in Equation 6 chooses $c^* = A \Leftrightarrow U_i = u_i^A$ and $c^* = B \Leftrightarrow U_i = u_i^B$, just as in the Bayesian Nash equilibrium. In the bidding stage, instead, the bid of Player 1 is affected by preference for freedom, non-interference, and power. Derivations of all measures ($\Phi_1^{f,c}$, $\Phi_1^{f,d}$, $\Phi_1^{ni,c}$, $\Phi_1^{ni,d}$, $\Phi_1^{p,d}$) for Treatments 1, 2, and 3 are given in Appendix A, and a summary is presented in Table 4.[14] With a slight abuse of notation, let $subg(\Game, y)$ refer to the subgame following a bid y by Player 1.

As an example, let us analyze the decision problem in Treatment 1 of a Player 1 with preference for freedom under the $\Phi^{f,c}$ specification. Intuitively,

[13]We are aware that this is a very crude way of comparing the qualitative difference of an element to a set. For the purposes of this experiment with essentially only two outcomes, such a simple metric will be sufficient. More sophisticated measures of qualitative diversity and their relation to difference metrics are given in Nehring and Puppe (2002). It may be interesting to consider experiments where outcomes have a qualitative difference aside from payoffs.

[14]Since games $\Game^p$ differ from games $\Game^{np}$ uniquely because of a positive payoff difference for Player 2, $\Delta\pi_2 = \pi_2^{high,L} - \pi_2^{low,L}$, we consider only the specification $\Phi^{p,d}$ for power.

Game	Specification	Measure
$\Game_1, \Game_2$	$\Phi^{f,c}$	$\frac{y}{100}$
$\Game_3$	$\Phi^{f,c}$	0
$\Game_1, \Game_2$	$\Phi^{f,d}$	$\frac{y}{100}\left(\pi_1^{high} - \pi_1^{low}\right)$
$\Game_3$	$\Phi^{f,d}$	0
$\Game_1, \Game_2, \Game_3$	$\Phi^{ni,c}$	$-\frac{100-y}{100}$
$\Game_1, \Game_2, \Game_3$	$\Phi^{ni,d}$	$-\frac{100-y}{100}\left(\pi_1^{high} - \pi_1^{low}\right)$
$\Game_1^p, \Game_2^p$	$\Phi^{p,d}$	$\frac{y}{100}\left(\pi_2^{high} - \pi_2^{low}\right)$
$\Game_1^{np}, \Game_2^{np}, \Game_3$	$\Phi^{p,d}$	0

Table 4: Freedom, power, and non-interference measures

freedom under this specification is equal to the probability of having the decision right. This is because, if Player 1 has the decision right, then $g(A, u_1^A)\log_2 \frac{\theta(A|u_1^A)}{\theta(A)} = g(B, u_1^B)\log_2 \frac{\theta(B|u_1^B)}{\theta(B)} = \log_2 \frac{1}{1/2} = 1$. If Player 1 does not have the decision right, then $g(o,u)\log_2 \frac{\theta(o|u)}{\theta(u)} = 0\ \forall o, u$. Thus, a Player 1 with preference for freedom chooses his bid to solve

$$\max_y V_1 = \max_y \alpha_1 \frac{y}{100} + \delta_1 EU_1(subg(\Game_1, \theta_{1|y})). \tag{10}$$

The optimal bid condition corresponding to Equation 7 then becomes

$$\alpha_1 + u(w_1 - y^{*F} + \pi_1^{high}) = \frac{1}{2}u(w_1 + \pi_1^{high}) + \frac{1}{2}u(w_1 + \pi_1^{low}). \tag{11}$$

This means that the utility from having the decision right is increased by a constant α_1. In Treatment 3, instead, in which by design Card C is the outcome of the game if Player 1 has the decision right, it would be $g(C, u_1^C)\log_2 \frac{\theta(C|u_1^C)}{\theta(C)} = g(C, u_1^C)\log_2 \frac{1}{1} = 0$, so freedom would be zero.

5 Empirical Strategy

Equation 11 gives an especially simple way of measuring Player 1's preference for freedom in a game of Treatment 1. The parameter α_1 can be inferred from a regression of the difference in estimated utilities from Box L and Box R, $\Delta EU_1 = u(w_1 - y + \pi_1^{high}) - \frac{1}{2}u(w_1 + \pi_1^{high}) - \frac{1}{2}u(w_1 + \pi_1^{low})$, on a constant.[15] A simi-

[15] The estimated utility from Box L in ΔEU_1 is computed setting $r = y$.

lar approach can be also applied to measuring Player 1's preference for non-interference and preference for power. For simplicity, since we consider only Player 1's behavior, we introduce a subscript denoting each subject in the sample who plays as Player 1. For each subject k playing as Player 1, we consider the following estimation equation:

$$\Delta EU_{k,t} = \alpha_k V^f_{k,t} + \beta_k V^{ni}_{k,t} + \gamma_k V^p_{k,t} + \varepsilon_{k,t} \tag{12}$$

where k stands for the subject, t for the round of play, and V^f, V^{ni}, V^p for the freedom, non-interference, and power variables, respectively, and where we normalized $\delta_k = 1$ of Equation 6 to achieve identification of α_k, β_k, and γ_k. Table 5 gives an overview of the measures and their empirical implementation.

Measure	Variable	Value
$\Phi^{f,c}$	$V^{f,c}$	$-1_{[\Game_1,\Game_2]}$
$\Phi^{f,d}$	$V^{f,d}$	$-1_{[\Game_1,\Game_2]}\Delta\pi_1$
$\Phi^{ni,c}$	$V^{ni,c}$	-1
$\Phi^{ni,d}$	$V^{ni,d}$	$-\Delta\pi_1$
$\Phi^{p,d}$	$V^{p,d}$	$-1_{[\Game^p_1,\Game^p_2]}\Delta\pi_2$

Table 5: Empirical implementation of measures
$1_{[\Game,\Game']} = 1$ if game is $\Game$ or $\Game'$ and $= 0$ otherwise.

As discussed above, in Treatment 1, the freedom measure $\Phi^{f,c}$ corresponds to a constant. The same holds in Treatment 2. In Treatment 3, instead, freedom is excluded by design.[16] Therefore, estimating preference for freedom under the specification $\Phi^{f,c}$ corresponds to running a regression on a dummy variable that equals 1 in Treatments 1 and 2 and 0 in Treatment 3, denoted $1_{[\Game_1,\Game_2]}$. Under the specification $\Phi^{f,d}$, the dummy is interacted with the payoff distance $\Delta\pi_1 = \pi_1^{high} - \pi_1^{low}$.

Unlike freedom, non-interference is present in all treatments.[17] Therefore, estimating preference for non-interference under the specification $\Phi^{ni,c}$ corresponds to running a regression on a constant. The specification $\Phi^{ni,d}$ takes into account the difference in payoffs $\Delta\pi_1$.

[16] In Treatment 3, Box L contains only 1 card, so even if his bid is successful, Player 1 does not select a card and thus has no freedom.

[17] In Treatment 3, Player 2 affects the outcomes of Player 1 if the bid is not successful; therefore, a successful bid yields non-interference for Player 1.

Power is present only in games $\Game^p$ in Treatments 1 and 2, denoted $\Game_1^p$ and $\Game_2^p$.[18] We focus on the specification $\Phi^{p,d}$ since games $\Game^p$ differ from $\Game^{np}$ uniquely because of a positive payoff distance for Player 2, $\Delta\pi_2 = \pi_2^{high,L} - \pi_2^{low,L}$. Thus, estimating preference for power under the specification $\Phi^{p,d}$ corresponds to running a regression on $\Delta\pi_2$ times a dummy variable that equals 1 in games $\Game^p$ in Treatments 1 and 2 and zero otherwise.

6 Results

6.1 Allocation and exercise of decision rights

Before turning to the results obtained via the empirical strategy described in the previous section, we briefly present descriptive results on how Player 1 bids for the decision right, and on how the player with the decision right (Player 1 or 2) makes the card selection.

First, we inspect whether bids differ across treatments. Table 6 reports the median bids submitted by Players 1 for each treatment and each round. For most rounds, bids in Treatment 3, in which the decision right gives Player 1 only non-interference, are significantly higher than in Treatment 1, in which the decision right additionally gives freedom ($\Game^{np}$) or power and freedom ($\Game^p$). This evidence suggests the key role of non-interference, which we further investigate later in this section.

Second, we inspect whether bids in games that do not involve power ($\Game^{np}$) differ from those in games that involve power ($\Game^p$). We make pair-wise comparisons across rounds in which Player 1 faces the same stake size and the same expected payoff. We compare round 5 to round 12 and round 10 to round 20.[19] We find no significant differences between $\Game^{np}$ and $\Game^p$ in either pair of comparisons.[20] This evidence suggests that considerations regarding power may be

[18]In Treatment 3, Box L contains only 1 card, so even if his bid is successful, Player 1 does not select a card and thus has no power over Player 2. In games $\Game^{np}$ in Treatments 1 and 2, Player 2's payoffs in box L are equal, $\pi_2^{high,L} = \pi_2^{low,L}$, so Player 1 has no power over Player 2. In games $\Game^p$ in Treatments 1 and 2, in contrast, Player 2's payoffs in box L differ, $\pi_2^{high,L} > \pi_2^{low,L}$, so Player 1 has power over Player 2.

[19]Player 1 faces a stake size of 25 and an expected payoff of 50 in rounds 5 and 12, and a stake size of 50 and an expected payoff of 50 in rounds 10 and 20.

[20]We perform a Wilcoxon signed rank sum test on observations paired at the participant level. For round 5 versus round 12, we have $z = 0.658$ ($p = 0.5102$) in Treatment 1 and $z = 1.339$

less relevant than considerations regarding freedom and non-interference. We further investigate this aspect later in this section.

Once the decision right is allocated, the player with the decision right makes the card selection. Recall from Section 3 that, if Player 1 has the decision right, he chooses a card from Box L, knowing which card gives him the highest payoff.[21] Similarly, if Player 2 has the decision right, he chooses a card from Box R, knowing which card gives him the highest payoff.[22] Do agents with the decision right use it in their favor, selecting the card that gives them the highest payoff? Pooling all data together, we find that, as Table 7 shows, in more than 98 percent of the observations, the decision right is exercised by selecting the card that gives the decision-maker his highest payoff.

Round	Treatment						
	1	2	3	all	1 vs 2	2 vs 3	1 vs 3
1	50	52	69	60			-2.492 (0.0127)
2	48	40	45	44		-2.357 (0.0184)	
3	28	30	30	30			-1.709 (0.0874)
4	45	40	60	50		-3.073 (0.0021)	-2.884 (0.0039)
5	40	40	45	40			-1.831 (0.0671)
6	30	30	30	30			-1.781 (0.0749)
7	50	40	70	50		-2.968 (0.0030)	-3.000 (0.0027)
8	30	36	45	35			-2.198 (0.0280)
9	20	30	30	30	-2.489 (0.0128)		-2.893 (0.003)
10	66	68	80	70		-1.945 (0.0518)	
11	40	40	45	40			-2.043 (0.0411)
12	35	36	45	40		-1.703 (0.0886)	-1.977 (0.0481)
13	35	40	50	40		-2.296 (0.0217)	-2.430 (0.0151)
14	33	35	43	40		-1.719 (0.0856)	-1.909 (0.0562)
15	30	30	45	40		-1.706 (0.0880)	-1.941 (0.0523)
16	50	40	65	50		-2.586 (0.0097)	-2.916 (0.0035)
17	25	30	30	30			-2.411 (0.0159)
18	40	47	50	48		-1.860 (0.0628)	-2.614 (0.0089)
19	30	31	35	33			
20	80	70	70	72			
all	40	40	50	40			

Table 6: Median bids. Results of a Mann-Whitney-Wilcoxon rank-sum test (*p*-values in parentheses) are reported only for statistically significant cases.

$(p = 0.1806)$ in Treatment 2. For round 10 versus round 20, we have $z = -1.143$ $(p = 0.2531)$ in Treatment 1 and $z = -1.356$ $(p = 0.1750)$ in Treatment 2. In Treatment 3, as highlighted in Section 3.2, all rounds involve non-interference but do not involve either freedom or power. Therefore, distinguishing between ∂^{np} and ∂^{p} in Treatment 3 is not meaningful.

[21] In Treatments 1 and 2, the highest payoff for Player 1 is generated by Card B in case 1 and 2 and by Card A in case 3 and 4, as shown in Figure 1. In Treatment 3, Box L contains only Card C, making the choice of Player 1 trivial.

[22] In Treatments 1 and 2, the highest payoff for Player 2 is generated by Card B in case 1 and 3 and by Card A in case 2 and 4, as shown in Figure 1.

Treatment	Player 1		Player 2	
	has decision right	chooses preferred card	has decision right	chooses preferred card
1	0.41	1	0.59	0.98
2	0.4	0.99	0.6	0.99
3	0.55	1	0.45	0.94
all	0.44	1	0.56	0.98

Table 7: Decision rights and choice behavior conditional on having the decision right. Fraction of observations.

6.2 Certainty equivalents

To verify whether subjects playing as Player 1 behave according to expected utility maximization, we compare the certainty equivalent in each lottery-choice in Part 2, $CE_{lottery}(L)$ with $L = (\frac{1}{2}, \pi_1^{high}; \frac{1}{2}, \pi_1^{low})$, to the certainty equivalent implied in the bidding choice in the corresponding situation in Part 1, i.e., involving the same π_1^{high} and π_1^{low}:

$$\pi_1^{high} - y = CE\left(\frac{1}{2}, \pi_1^{high}; \frac{1}{2}, \pi_1^{low}\right). \tag{13}$$

Denote ΔCE as

$$\Delta CE = \pi_1^{high} - y - CE_{lottery}\left(\frac{1}{2}, \pi_1^{high}; \frac{1}{2}, \pi_1^{low}\right). \tag{14}$$

Overbidding occurs if ΔCE is negative: the subject exhibits more risk aversion in the bidding choice than in the lottery choice. Underbidding occurs if ΔCE is positive: the subject exhibits more risk aversion in the lottery choice than in the bidding choice.[23]

If the only error in ΔCE is due to the imprecise measurement of the certainty equivalent (which is measured at intervals of 5 payoff units), we should expect ΔCE to be distributed uniformly with mean 0 and standard deviation $(25/12)^{1/2} \approx 1.44$. We find instead that the mean is too low (-14.11) and the standard deviation is too high (25.41).[24] Both deviations are significant at the 1% level. We therefore reject the hypothesis of expected-utility-maximizing

[23]We are aware of a caveat. When subjects answered the lottery-choice questionnaire in Part 2, they already knew their endowment in Part 1 (w_1), but they did not know their earnings in Part 1 yet. Therefore, if there are significant income effects on risk aversion, we cannot expect Equation 9 to be identical to Equation 13.

[24]The empirical distribution of ΔCE over 1132 observations has mean -14.11, median -12.50, 25% percentile -27.5, 75% percentile 2.5, and standard deviation 25.41.

behavior.

6.3 Risk preferences

Among the variables defined in Section 5, ΔEU requires knowledge of an individual's utility function over payoffs, $u(\pi)$. We approximate $u(\pi)$ by a CRRA utility function $u(\pi) = \frac{\pi^{1-\rho}}{1-\rho}$. For each subject, we estimate his risk aversion coefficient via maximum likelihood estimation from his responses in the lottery-choice questionnaire in Part 2 using a random utility model with

$$u_k\left(\frac{1}{2}, \pi^{high,q}; \frac{1}{2}, \pi^{low,q}\right) = \frac{(\pi^{high,q})^{1-\rho_k}}{2(1-\rho_k)} + \frac{(\pi^{low,q})^{1-\rho_k}}{2(1-\rho_k)} + \varepsilon_{q,k} \tag{15}$$

where $\varepsilon_{q,k} \sim_{iid} N(0, \sigma_k^2)$ and k indicates the subject and q indicates the lottery in question.

We are able to estimate the risk aversion coefficients for 235 out of 244 subjects: nine subjects exhibit such extreme risk preferences in the lottery-choice questionnaire that we are unable to fit a CRRA model. In general, risk preferences range from slightly risk loving to strongly risk averse.[25] Based on the risk aversion coefficients, we calculate the expected utility values of the payoffs from Box L and Box R.

6.4 Preference for freedom, non-interference, and power

As a preliminary analysis, we perform a linear regression on the whole dataset for different combinations and specifications of V^f, V^{ni}, and V^p. We assume that, for each individual k, $\alpha_k = \alpha$, $\beta_k = \beta$, and $\gamma_k = \gamma$; i.e., preferences for freedom, non-interference, and power are homogeneous across individuals. Thus, Equation 12 simplifies to the population regression

$$\Delta EU_{k,t} = \alpha V^f_{k,t} + \beta V^{ni}_{k,t} + \gamma V^p_{k,t} + \varepsilon_{k,t} \tag{16}$$

Results are reported in columns 1-4 of Table 8. We find no conclusive evidence of preference for freedom. Preference for power is neither statistically

[25] The empirical distribution of $\hat{\rho}$ over 235 observations has mean 0.59, median 0.37, 25% percentile 0.28, 75% percentile 0.46, and standard deviation 2.58.

	Equation 16				Equations 17-22	
	1	2	3	4	I	II
$V^{f,c}$	-1.748		0.565		0.1895	
	(1.935)		(1.427)		(0.7423)	
$V^{f,d}$		-0.029		-0.059		-0.0077
		(0.053)		(0.065)		(0.0192)
$V^{ni,c}$	6.711***	6.082***				5.6507***
	(1.520)	(1.163)				(0.4032)
$V^{ni,d}$			0.171***	0.218***	0.2081***	
			(0.039)	(0.049)	(0.0291)	
$V^{p,d}$	0.004	-0.0004	-0.007	0.008		
	(0.005)	(0.005)	(0.005)	(0.005)		
obs	2360	2360	2360	2360	2360	2360
subjects	118	118	118	118	117	117
F-test	12.7	12.71	11.11	11.65		
R-squared	0.1556	0.1539	0.1405	0.1425		
J test $\chi^2(1)$					0.0319	0.0591

Table 8: Columns 1-4 report the estimation results of the model from Equation 16. Standard errors are clustered at the individual level and are shown in parentheses: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Columns I and II report the estimation results of the model from Equations 17-22. In I and II we used simulated annealing with 1000 search points and the estimation of parameters and weighting matrix was iterated five times to achieve better finite-sample properties. To avoid misspecification, we excluded one individual who perfectly maximized expected payoffs. This does not affect the statistical or economic significance of the results. Standard errors are shown in parentheses: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. J test $\chi^2(1)$ is the Hansen test of over-identifying restrictions. Since $\chi^2(1)_{.05} = 3.841$, we do not reject the null hypothesis of a correctly specified model in either column I or II.

nor economically significant. Instead, we find that the effect of preference for non-interference is both economically and statistically significant. The best fit is provided by the model in column 1, where both the freedom variable and the non-interference variable are specified as constants. Given the estimated non-interference parameter, Player 1 experiences a utility loss of 6.711 when the decision right is given to Player 2. Interpreting such utility loss is not straightforward since a utility unit has different meanings for different subjects depending on their risk aversion. To provide an interpretation, we consider a Player 1 with median risk aversion ($\rho = 0.37$), and we look at what reduction in his endowment would generate a utility loss equivalent to that generated by not having the decision right. As an example, let us consider round 10 of Treatment 1, in which Player 1 has an endowment $w_1 = 100$ and potential payoffs $\pi_1^{high} = 100$ and $\pi_1^{low} = 0$. For this Player 1, a reduction in the endowment from 100 to 65 would generate a utility loss equivalent to that generated by not having the decision right.

A limitation of the population regression from Equation 16 is that it estimates a single vector of parameters (α, β, γ) for all individuals even though their ΔEU will differ in scale and standard deviation after the estimation of each individual's risk aversion coefficient.

We therefore estimate a more general model that allows for heterogeneous preferences across individuals. Since power is not a statistically significant explanatory variable in the estimation of the homogeneous-preferences model, we exclude it from the estimation of the heterogenous-preferences model and consider

$$\Delta EU_{k,t} = \alpha_k V_{k,t}^{f} + \beta_k V_{k,t}^{ni} + \varepsilon_{k,t}, \tag{17}$$

which we interpret as a random coefficient model with $\alpha_k = \alpha + \varepsilon_{\alpha,k}$ and $\beta_k = \beta + \varepsilon_{\beta,k}$. We estimate the random coefficient model using the following moment conditions:

$$E[\varepsilon_{k,t} V_{k,t}^{f}] = 0 \tag{18}$$

$$E[\varepsilon_{k,t} V_{k,t}^{ni}] = 0 \tag{19}$$

$$E[\varepsilon_{\alpha,k} - \alpha] = 0 \tag{20}$$

$$E[\varepsilon_{\beta,k} - \beta] = 0 \tag{21}$$

$$E[\varepsilon_{\beta,k} 1_{k,[\eth 3]}] = 0 \tag{22}$$

Conditions 18-19 state that errors $\varepsilon_{k,t}$ are independent of the regressors, the freedom variable $V_{k,t}^{f}$ and the non-interference variable $V_{k,t}^{ni}$, respectively. Conditions 20-21 identify the population parameters α and β. Condition 22 states that the mean of individual non-interference parameters in Treatment 3 is equal to that of the other treatments. Since treatment assignment was random, individuals' preference for freedom or non-interference should be independent across treatments. This allows identification of the freedom parameters α_k for individuals in Treatments 1 and 2. Without condition 22 we cannot distinguish whether their bidding behavior was motivated by preference for freedom or preference for non-interference. However, assuming that the mean preference parameters are identical across treatments, we can identify the mean α via the difference in behavior between Treatment 3 and the other treatments.

Results of the random coefficient model from Equations 17-22 are reported in columns I-II of Table 8. The previous results are confirmed. Preference for non-interference is the driving force for preference for decision rights. Therefore, the economic significance of the coefficient of preference for non-interference in the population regression 16 is not simply driven by a few individuals with high risk aversion. The median coefficients of preference for non-interference in columns I and II are 0.04 and 1.70, respectively. To provide an interpretation, we compute, as done above for the population regression, the reduction in endowment that would generate for a Player 1 with median risk aversion ($\rho = 0.37$) in round 10 of Treatment 1 a utility loss equivalent to that generated by not having the decision right. The endowment would need to be reduced by 10.37 points in column I and by 12.38 points in column II.

Additionally, in Appendix C, we use the estimates obtained for individual-level α_k and β_k to examine whether preference for freedom and non-interference can be explained by individuals' locus of control, which is measured in Part 3 of the experiment. We find that one of the three separate scales used to measure locus of control, the P-scale, which measures the degree to which individuals believe that other persons control their lives, explains preference for freedom and non-interference in model I, but not in model II. Thus, the evidence suggests that preference for freedom and non-interference cannot be fully explained by locus of control.[26]

We are aware of several limitations in our results. The weak evidence of preference for power may be driven partly by the experimental setting, in which each player learned his own preferences over the final outcomes but never learned the preferences of the other player. Therefore, a Player 1 with preference for power may not find the exercise of power over Player 2 particularly satisfying because he does not know Player 2's preferences over outcomes. Experimental settings that relax such information constraints may shed further light on the role of preference for power. We consider this an interesting direction for further research.

Further, preference for non-interference may be driven by ambiguity aversion. If a subject believes that other individuals, when they have the decision right, will not necessarily choose the option in their best interest, then he will perceive strategic uncertainty with respect to the types of individuals he is facing.

[26] For details, see Appendix C.

However, evidence from our experiment seems not to support this conjecture. Almost all the participants in our experiment chose the option in their best interest. Thus, to fully explain the extent of preference for non-interference, we would need to posit either very strong ambiguity aversion or beliefs about other players that are far off the equilibrium path.

7 Conclusions

In this paper, we present theoretical foundations for preference for decision rights, driven by preference for freedom, power, and non-interference. We conduct a laboratory experiment in which the role of each preference can be distinguished.

Our results confirm the existence of an intrinsic value of decision rights and extend it from delegation settings to a willingness to pay/auction setting. Evidence from our experiment highlights two main results. First, we find no evidence of preference for power. Thus, preference for power, as casually observed in politics or other institutional settings, may simply be instrumental to other components of well-being, such as status recognition. This result, however, may partly depend on the experimental setting, in which each player learns his own preferences over the final outcomes but never learns the preferences of the other player. Therefore, a Player 1 with preference for power may not find the exercise of power over Player 2 particularly satisfying because he does not know Player 2's preferences and thus does not know how he can influence him. We consider experimental settings that relax such information constraints an interesting direction for further research.

Second, we find stronger evidence of preference for non-interference than for freedom. This result suggests that individuals value the decision right not because of the actual decision-making process but rather because they have preference against others intervening in their outcomes. This result leads to a fundamental change in perspective on preference for decision rights. In contrast to the interpretation presented by Fehr et al. (2013) and Bartling et al. (2014), individuals like to have decision rights in virtue of the absence of decision rights of other individuals. An individual's evaluation of risks then depends on whether the risks are generated by an objective process or by the behavior of other individuals.

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Appendix

A Derivations of valuation functions

In this appendix we present the derivation of the measures of freedom Φ_1^f, non-interference Φ_1^{ni}, and power Φ_1^p under each specification of function $g(o,u)$ ($g = 1$ and $g = |\pi^{high} - \pi^{low}|$) and for each treatment (1, 2 and 3).

The freedom measure Φ_1^f under Treatment 1 for a general function g is:

$$\Phi_1^f(subg(\eth_1, y), \theta_{1|y}) = \\ \sum_{r \le y} \sum_{u \in U_1} \theta_{1|y}(u) \sum_{c \in \{A,B\}} g(o(r,1,c),u)\theta_{1|y}(o(r,1,c)|u) \log_2 \frac{\theta_{1|y}(o(r,1,c)|u)}{\theta_{1|y}(o(r,1,c))} + \\ + \sum_{r > y} \sum_{u \in U_1} \theta_{1|y}(u) \sum_{c \in \{A,B\}} g(o(r,2,c),u)\theta_{1|y}(o(r,2,c)|u) \log_2 \frac{\theta_{1|y}(o(r,2,c)|u)}{\theta_{1|y}(o(r,2,c))}, \tag{23}$$

where we use the fact that $\sum_{o \in O_i} f(o) = \sum_{r=1}^{100} \sum_{i \in \{1,2\}} \sum_{c \in \{A,B\}} f(o(r,i,c))$ for any function $f(o)$ and that $y \ge r$ implies $\theta_{1|y}(o(r,2,c)) = 0$. Moreover, $\theta_{1|y}(o(r,2,c)|u) = \theta_{1|y}(o(r,2,c))$ since if Player 2 has the decision right, the outcome is independent of Player 1's preferences. Since $\log_2 1 = 0$, the measure simplifies to:

$$\Phi_1^f(subg(\eth_1, y), \theta_{1|y}) = \\ \sum_{r \le y} \sum_{u \in U_1} \theta_{1|y}(u) \sum_{c \in \{A,B\}} g(o(r,1,c),u)\theta_{1|y}(o(r,1,c)|u) \log_2 \frac{\theta_{1|y}(o(r,1,c)|u)}{\theta_{1|y}(o(r,1,c))} \tag{24}$$

The remaining probabilities are as follows:

$$\begin{aligned}
\forall u \in U_1: \quad & \theta_{1|y}(u) = 1/2 \\
\forall u \in U_1 : \forall r \le y: \quad & \theta_{1|y}(o(r,1,A)|u) = \begin{cases} \frac{1}{100}, & u = u_1^A \\ 0, & \text{else} \end{cases} \\
\forall u \in U_1 : \forall r \le y: \quad & \theta_{1|y}(o(r,1,B)|u) = \begin{cases} \frac{1}{100}, & u = u_1^B \\ 0, & \text{else} \end{cases} \\
\forall r \le y: \quad & \theta_{1|y}(o(r,1,A)) = 1/200 \\
\forall r \le y: \quad & \theta_{1|y}(o(r,1,B)) = 1/200
\end{aligned} \tag{25}$$

The freedom measure therefore simplifies to:

$$\Phi_1^f(subg(\Game_1,y),\theta_{1|y}) = \frac{1}{200}\sum_{r\leq y}(g(o(r,1,A),u_1^A)+g(o(r,1,B),u_1^B)) \tag{26}$$

Since Treatment 2 differs from Treatment 1 only in that Player 2's endowment w_2 equals 0 instead of 100, it follows that $\Phi_1^f(subg(\Game_1,y),\theta_{1|y}) = \Phi_1^f(subg(\Game_2,y),\theta_{1|y})$. For Treatment 3, instead:

$$\begin{aligned}
&\Phi_1^f(subg(\Game_3,y),\theta_{1|y}) = \\
&\sum_{r\leq y}\sum_{u\in U_1}\theta_{1|y}(u)\sum_{c\in\{C\}} g(o(r,1,c),u)\theta_{1|y}(o(r,1,c)|u)\log_2\frac{\theta_{1|y}(o(r,1,c)|u)}{\theta_{1|y}(o(r,1,c))}+ \\
&+\sum_{r>y}\sum_{u\in U_1}\theta_{1|y}(u)\sum_{c\in\{A,B\}} g(o(r,2,c),u)\theta_{1|y}(o(r,2,c)|u)\log_2\frac{\theta_{1|y}(o(r,2,c)|u)}{\theta_{1|y}(o(r,2,c))},
\end{aligned} \tag{27}$$

As in (23), $\theta_{1|y}(o(r,2,c)|u) = \theta_{1|y}(o(r,2,c))$: if Player 2 has the decision right, the outcome is independent of Player 1's preferences. In addition, $\theta_{1|y}(o(r,1,C)|u) = \theta_{1|y}(o(r,1,C))$: if Player 1 has the decision right, then only Card C is available, so the outcome is independent of Player 1's preferences. Since $\ln_2 1 = 0$, the measure equals $\Phi_1^f(subg(\Game_3,y),\theta_{1|y}) = 0$. This concludes the derivations for freedom Φ^f.

The non-interference measure Φ_1^{ni} for a general function g is:

$$\begin{aligned}
&\Phi_1^{ni}(subg(\Game,y),\theta_{1|y}) = \\
&-\sum_{r\leq y}\sum_{v\in U_2}\theta_{1|y}(v)\sum_{u\in U_1}\theta_{1|y}(u|v)\sum_{c\in\{A,B\}} g(o(r,1,c),u)\theta_{1|y}(o(r,1,c)|v)\log_2\frac{\theta_{1|y}(o(r,1,c)|v)}{\theta_{1|y}(o(r,1,c))}+ \\
&-\sum_{r>y}\sum_{v\in U_2}\theta_{1|y}(v)\sum_{u\in U_1}\theta_{1|y}(u|v)\sum_{c\in\{A,B\}} g(o(r,2,c),u)\theta_{1|y}(o(r,2,c)|v)\log_2\frac{\theta_{1|y}(o(r,2,c)|v)}{\theta_{1|y}(o(r,2,c))}
\end{aligned} \tag{28}$$

In all treatments, $\theta_{1|y}(o(r,1,c)|v) = \theta_{1|y}(o(r,1,c))$: if Player 1 has the decision right, the outcome is independent of Player 2's preferences. Thus, Φ_1^{ni} can be written, for all treatments, as:

$$\begin{aligned}
&\Phi_1^{ni}(subg(\Game,y),\theta_{1|y}) = \\
&-\sum_{r>y}\sum_{v\in U_2}\theta_{1|y}(v)\sum_{u\in U_1}\theta_{1|y}(u|v)\sum_{c\in\{A,B\}} g(o(r,2,c),u)\theta_{1|y}(o(r,2,c)|v)\log_2\frac{\theta_{1|y}(o(r,2,c)|v)}{\theta_{1|y}(o(r,2,c))}
\end{aligned} \tag{29}$$

Since the non-interference measure captures "interferences", it captures what happens if Player 2 has the decision right, and not what happens if Player 1 has the decision right. The remaining probabilities are as follows:

$$
\begin{aligned}
\forall v \in U_2: \quad & \theta_{1|y}(v) = 1/2 \\
\forall v \in U_2 : \forall u \in U_1: \quad & \theta_{1|y}(u|v) = 1/2 \\
\forall v \in U_2 : \forall r \leq y: \quad & \theta_{1|y}(o(r,2,A)|v) = \begin{cases} \frac{1}{100}, & v = u_2^A \\ 0, & \text{else} \end{cases} \\
\forall v \in U_2 : \forall r \leq y: \quad & \theta_{1|y}(o(r,2,B)|v) = \begin{cases} \frac{1}{100}, & v = u_2^B \\ 0, & \text{else} \end{cases} \\
\forall r \leq y: \quad & \theta_{1|y}(o(r,2,A)) = 1/50 \\
\forall r \leq y: \quad & \theta_{1|y}(o(r,2,B)) = 1/50
\end{aligned} \tag{30}
$$

The non-interference measure therefore simplifies to:

$$
\Phi_1^{ni}(subg(\eth,y),\theta_{1|y}) = -\frac{1}{400}\sum_{r>y}\sum_{u\in U_1}\left(g(o(r,2,A),u) + g(o(r,2,B),u)\right) \tag{31}
$$

It is then straightforward to insert the values for $g(o,u)$ in the above equations. Summing up, for freedom we have:

$$
\begin{aligned}
&\Phi^{f,c}(subg(\eth_1,y),\theta_{1|y}) = \Phi^{f,c}(subg(\eth_2,y),\theta_{1|y}) = \frac{y}{100} \\
&\Phi^{f,d}(subg(\eth_1,y),\theta_{1|y}) = \Phi^{f,d}(subg(\eth_2,y),\theta_{1|y}) = \frac{y}{100}\left(\pi_1^{high} - \pi_1^{low}\right) \\
&\Phi^{f,c}(subg(\eth_3,y),\theta_{1|y}) = \Phi^{f,d}(subg(\eth_3,y),\theta_{1|y}) = 0
\end{aligned} \tag{32}
$$

For non-interference we have for all $\eth \in \{\eth_1, \eth_2, \eth_3\}$:

$$
\begin{aligned}
\Phi^{ni,c}(subg(\eth,y),\theta_{1|y}) &= -\frac{100-y}{100} \\
\Phi^{ni,d}(subg(\eth,y),\theta_{1|y}) &= -\frac{100-y}{100}\left(\pi_1^{high} - \pi_1^{low}\right)
\end{aligned} \tag{33}
$$

Power is largely analogous to $\Phi^{f,d}$ and therefore gives:

$$
\begin{aligned}
\Phi^{p,d}(subg(\eth_1^{p},y),\theta_{1|y}) = \Phi^{p,d}(subg(\eth_2^{p},y),\theta_{1|y}) &= \frac{y}{100}\left(\pi_2^{high} - \pi_2^{low}\right) \\
\Phi^{p,d}(subg(\eth_1^{np},y),\theta_{1|y}) = \Phi^{p,d}(subg(\eth_2^{np},y),\theta_{1|y}) &= 0 \\
\Phi^{p,d}(subg(\eth_3,y),\theta_{1|y}) &= 0
\end{aligned} \tag{34}
$$