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Concord and contention in a dynamic unstructured bargaining experiment with costly conflict[☆]

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ABSTRACT

We report experimental results from a dynamic real-time bargaining experiment. Players earn flows of income from the assets they possess at any point in the bargaining process, while they incur costs which are proportional to the size of the conflict between players' current claims. We find that most bargaining interactions are characterised by small but non-zero amounts of contention, which arises from the process of tacitly coordinating claims, including from negotiating turn-taking approaches. Interactions with large losses from contention occur in a sizeable minority of interactions. There are significant individual differences in outcomes across participants. We do not find systematic gender effects, but do find that the locus of control of participants predicts bargaining outcomes.

1. Introduction

Bargaining interactions are integrated in many parts of the flow of day-to-day life. A child setting up a mock tea party and another child setting up a make-believe construction site may be in contention over whether a teddy bear will be the guest of honour or the foreman, while each carries on their play activity even while pursuing the dispute. Companies may dispute intellectual property rights over an innovation while the remainder of the business carries on. Countries contest control over territory, and oil, gas, mineral, and fishing resources, while economic activity in undisputed regions carries on largely unaffected. The flows of benefits from the assets controlled by each player continue in parallel to the costs incurred due to arguing, litigating, or fighting militarily over the objects under dispute.

Such unstructured interactions offer rich opportunities for agents to take different approaches to claiming resources and to resolving (or not) conflicts among claims. However, the flip side of the potential richness of interaction is that, as is often the case in repeated games, there is a large set of behaviours which are consistent with strategic equilibrium. Placing additional structure on bargaining can sometimes produce sharper theoretical predictions, such as the alternating-moves approach of Rubinstein (1982) or the legislative bargaining model of Baron and Ferejohn (1989). But, most bargaining is not done under a formal set of rules as in a legislature, and partial, tentative bargains may be made – and then subsequently un-made – as the overall interaction progresses.

In this paper we study unstructured bilateral bargaining over an odd number of equally valuable assets. At any point in time, each player can claim a subset of the assets. Assets which are claimed only by one player generate a flow of earnings to that player,

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while those which are claimed by both players result in both players incurring costs as long as the overlapping claims persist. Players are free to revise their claims at any time, and in making changes to their claims they are unconstrained by any past claims they may or may not have made.

We show in our brief theoretical treatment in Section 2 that in this setting a wide variety of outcomes are consistent with subgame-perfect Nash equilibrium. Conflict arising from both players claiming the same assets can persist in equilibrium throughout a bargaining interaction, leading to arbitrarily inefficient outcomes. We refer to the overlap of claims, and the resulting costs, as *contention* between the players. On the positive side, there are many equilibria which achieve efficiency, in which exactly one player claims each asset at each point in time; furthermore efficiency and equity can be achieved through the use of turn-taking strategies which address the tension arising from the odd number of assets. We refer to such successful allocation as *concord*, in reflection of the state of (provisional) agreement it represents.[1]

The possibility of concord and contention – not just across equilibria, but potentially co-existing at any point in time – makes our experiment complementary to, but distinct from, two existing strands of the literature. On the one hand, there is the literature which emphasises the coordination aspect of bargaining. This is exemplified by the tacit bargaining approach of Isoni et al. (2013), among others. In this literature, claims over a set of assets are made simultaneously by two players, with successful division occurring when there are non-overlapping claims. In these approaches, bargaining is either successful or not, and the task of a player who wants to achieve a successful bargain is, in essence, to identify a claim to make which will lead to concord. However, because the interaction is one-shot, players do not have any opportunity to react to and deal with any contention that arises, nor to use contention as a bargaining tool to influence outcomes.

In a dynamic setting, players may find themselves in a situation where there is contention over assets. Such a situation has the flavour of a war of attrition (Smith, 1974): on the assets in contention, both players will suffer costs until one of them chooses to yield their claim to that asset. Wars of attrition arise, among other situations, in market exit games (Bulow & Klemperer, 1997; Fudenberg & Tirole, 1986). There are a few papers which study these games experimentally, including Bilodeau et al. (2004) and Oprea et al. (2013). However, those environments start by placing the players in a state of contention over, essentially, a single asset, and the only way out of contention is to yield.

By design our unstructured environment does not include any of the assumptions made in non-cooperative game models that restrict the set of equilibrium outcomes. Equilibrium selection is therefore an empirical matter, and our principal research question is simply to explore how people conduct unstructured bargaining when concord and contention are phenomena possible both in the game itself and in equilibrium. In particular, we are interested to know to what extent individual differences may play a role in bargaining outcomes. Send and Serena (2022) have used a large dataset of bilateral bargaining interactions from eBay to demonstrate that sellers systematically differ in their insistence — the unwillingness to make immediate concessions from their originally-offered price. The presence of both concord and contention means that both cooperative and competitive motives could be at work; many studies have looked at individual traits with respect to cooperation and competition (e.g. Cason et al., 2013; Isoni et al., 2013, 2014; Lau & Mui, 2008; Ponsati & Sákovics, 1995; Sibly et al., 2015). There are many individual characteristics which could be correlated with bargaining approaches. In designing this experiment, we chose to look at two which have received significant previous attention, and based on previous results are likely to have some relevance in our setting: *gender* and *locus of control*.

The role of gender differences in bargaining has received increasing attention, not least because such differences may be implicated in lower earnings and less career advancement for women. Several studies, including Gneezy et al. (2003), Gneezy and Rustichini (2004), and Niederle and Vesterlund (2007) have found that females tend to shy away from competitive environments relative to their male counterparts. In contrast, in non-physical conflict situations, Björkqvist (1994) and Hyde (2005) find that females are at least as aggressive as males. Specifically with respect to bargaining, in a natural field experiment Leibbrandt and List (2015) found that women were less likely than men to initiate bargaining over wages when the possibility of negotiation was not explicitly mentioned. Taken together these would suggest women tend to avoid selecting into situations in which conflict is likely. However, Leibbrandt and List report that when wages were advertised as negotiable, gender differences disappeared. In their survey, Croson and Gneezy (2009) summarise similar results from economics and psychology: women are less likely to initiate negotiation, but roughly as effective at negotiation once initiated. Further, Exley et al. (2020) find evidence that some of the difference in the propensity of women to initiate bargaining can be attributed to women knowing when bargaining will lead to better outcomes. Malik et al. (2021) report on an experiment on gender differences in a bargaining environment; they find men are more likely to follow a strategy of not backing down from a fixed bargaining position, but only when the players do not know the gender of their coplayer. It is therefore ambiguous whether men and women will differ systematically in our environment: although inherently our environment is a bargaining setting, it is still possible to "opt-out" partially by avoiding contention.

Rotter (1966) introduced the concept of *locus of control* (LOC), which captures a person's perception of causality in their immediate environment. This scale classifies people as tending to have an internal or external locus of control. A person with an *internal LOC* perceives himself or herself to be in control of or capable of influencing events affecting them. In contrast, a person with an *external LOC* believes that events influencing their life are determined predominantly by chance or other factors beyond their control. Lange and Tiggemann (1981) reported a high test-retest reliability for Rotter's scale, and Marsh and Richards (1986) found responses to Rotter's instrument were comparable across different response formats.

[1] We choose "concord", with some poetic license, as an antonym for "contention". Words such as "contention" or "conflict" are widely used to denote states where inefficiencies occur, such as overlapping claims in our environment. There is not a parallel standard word that, in our view, captures succinctly the sense of successful division.

Many applications of locus of control to economic decision making are in domains in which outcomes of decisions are realised farther into the future, and/or where the determinants of outcomes are ambiguous or otherwise difficult to discern. People with an internal locus of control are more likely, for example, to choose diet and exercise patterns typically associated with better long-term health outcomes (Cobb-Clark et al., 2014); to invest time in early-childhood skill formation for their children (Lekfuangfu et al., 2018); to adopt innovative business strategies in stable industries (Wijbenga & van Witteloostuijn, 2007); and to save more frequently and larger amounts over the longer term (Bucciol & Trucchi, 2021).

Bargaining environments differ from the previous examples in that outcomes are determined in the near future, and are the result of well-defined interactions, whether structured, semi-structured, or unstructured, with another person. Previous studies have found that a person's locus of control correlates with their approach to bargaining (e.g. Assor & O'Quin, 1982; Cupach et al., 2009; Lefcourt, 1972, 2014). Specifically, Bobbitt (1967) and Wall (1977) have shown that people with an internal LOC are more likely to adapt their approach in response to the actions of their co-player. When some with an internal LOC bargains against someone who takes a more competitive stance, they tend to respond more cooperatively and concede more; however, when bargaining against someone taking a more cooperative approach, someone with an internal LOC will make larger demands.

We find that, overall, full concord is common: at any given point in time, in a majority of interactions there are no assets in contention, and the percentage of interactions without contention tends to increase over time. However, participants do learn to use small amounts of contention to influence their bargaining outcomes, without necessarily leading to conflict spilling over to multiple assets. Individual participants do differ significantly in their propensities to claim assets, to engage in contention, and as a result in their net earnings. We do not find significant gender effects, but do find that locus of control predicts outcomes: most strongly, pairs in which the locus of control of the participants is more different tend to experience lower costs of contention.

Our experimental setting, and in particular the "bargaining table" layout of assets on a grid, extends the work of Isoni et al. (2014), who likewise consider interactions in which two participants bargain interactively during a time interval over a collection of assets. While building on the bargaining table platform, we address a different set of questions. Our design is informed by their finding that spatial layout cues can matter; because this is not our primary question, we vary the layouts of the assets on the table and then check whether there are significant effects, which we do not find. More crucially, in our setting payoffs are accumulated as the bargaining progresses, rather than leading to one final allocation. For example, in their setting "brinksmanship" – retaining a claim on an asset also claimed by the other participant – is completely costless, except for the risk of disagreement should neither player rescind the conflicting claim at the deadline. Having costly contention allows us to explore a richer environment, in which there are equilibria in which substantial amounts of contention, and therefore inefficiency, occur.

Luhan et al. (2017) also use a bargaining table layout, and, like us, allow payoffs to accrue in flows over time, but unlike us, do not have a positive cost of conflict. Their experiment focuses principally on the case in which there are a small number of assets, which have different values, and they focus on whether focal points can help players achieve agreement. In contrast, our experiment uses more assets, each with a smaller value, which allows us to look at how concord or contention can arise when players can adjust their claims on a much finer scale.

The rest of the paper is organised as follows. Section 2 introduces the bargaining game and illustrates why standard solution concepts do not constrain predictions on behaviour. Section 3 explains our experimental design and procedure. Section 4 outlines the research questions we address with the experimental design. Section 5 reports our results, and Section 6 concludes with a discussion.

2. The dynamic bargaining environment

Two players, A and B, bargain over a set of indivisible assets $\mathcal{D} = \{1, \ldots, D\}$. The bargaining takes place over a finite number of periods $T \geq 1$, indexed by $t = 1, \ldots, T$. In each period, the players $i \in \{A, B\}$ make simultaneous *claims*, each consisting of a subset of the assets. Formally, a claim is an action $a_i \in 2^{\mathcal{D}}$, where $2^{\mathcal{D}}$ denotes the set of subsets of $\mathcal{D}$. We use $\#a_i$ to denote the number of assets in a claim a_i. We follow the standard notational convention, such that $-i$ denotes the coplayer of i.

A pair of actions (a_i, a_{-i}) partitions the set of assets into four categories. Define $\pi_i(a_i, a_{-i}) = |a_i \cap a_{-i}^C|$ as the number of discs which player i claims and the other player $-i$ does not. We say that player i *possesses* these assets under that action profile, and refer to the proceeds player i receives as income. Let $\kappa(a_i, a_{-i}) = |a_i \cap a_{-i}|$ be the number of assets claimed by both players; we say these assets are *in contention*. Assets which are claimed by neither player are said to be *idle*.

Each player's payoff from the game is given by summing over all periods t the number of assets possessed, minus the number of assets which are in contention. Formally, let $\mathbf{a} = (a_A^t, a_B^t)_{t=1}^T$ denote the sequence of action pairs realised during a play of the game. Then the payoff to player i is

$$u_i(\mathbf{a}) = \sum_{t=1}^{T} \pi_i(a_i^t, a_{-i}^t) - \kappa(a_i^t, a_{-i}^t). \quad (1)$$

In each period t, both players know the full history of claims in periods $1, \ldots, t-1$. Let $\mathcal{H}_t$ denote the set of possible histories prior to period t, and let $\mathcal{H} = \cup_{t=1}^T \mathcal{H}_t$ be the set of all histories. A *strategy* s_i for player i specifies an action for each possible history, $s_i : \mathcal{H} \to 2^{\mathcal{D}}$.

We now develop the observation that the set of pure-strategy subgame-perfect equilibria (SPE) of this game is very large, and that there exist SPE which are efficient, as well as SPE in which contention and/or idleness occur on the path of play.

We begin with a straightforward observation about the one-shot version of the bargaining game.

Observation 1. *If $T = 1$, then a pure-strategy profile (a_A, a_B) is a Nash equilibrium if and only if it partitions the set of assets: $a_A \cup a_B = \mathcal{D}$ and $a_A \cap a_B = \emptyset$. These equilibria are all efficient; there is no contention and no idleness.*

This multiplicity of equilibria in the stage game generates in turn a multiplicity of SPE in the general case of $T > 1$. As is standard, we can construct a SPE by specifying, for each period t, an action profile which forms a Nash equilibrium of the game with $T = 1$, and specifying that action profile is played in period t irrespective of the history of play. Observe that we are free to choose which stage-game equilibrium is played unconditionally at each period. Based on constructions of this form, we can make this observation.

Observation 2. *In an efficient play of the game, the sum of the players' payoffs is $D \cdot T$. For any division of $D \cdot T$ between the two players, there exists a SPE which achieves that division. In particular, if T is even, there exist SPE with equal division between the players.*

All efficient allocations are attainable by a suitably constructed SPE; however, there also generically exist SPE in which idleness and/or contention occur. We can construct these SPE by again using the technique of choosing which stage-game equilibrium is played (unconditionally) in continuations.

Example 3 (*Idleness: a "Neutral" or "Buffer" Zone*). Let $D = \{1, 2, 3\}$ and $T = 2$. At $t = 1$, the players claim $a_A = \{1\}$ and $a_B = \{3\}$, leaving asset 2 idle. Play at $t = 2$ depends on the claims made at $t = 1$:

- If at $t = 1$ the players' claims were $a_A = \{1\}$ and $a_B = \{3\}$, then at $t = 2$ player A claims $\{1, 2\}$ and player B claims $\{3\}$.
- If at $t = 1$ player B claims $\{3\}$ and player A makes any claim other than $\{1\}$, then at $t = 2$ player B claims $\{1, 2, 3\}$ and player A claims $\emptyset$.
- If at $t = 1$ player A claims $\{1\}$ and player B makes any claim other than $\{3\}$, then at $t = 2$ player A claims $\{1, 2, 3\}$ and player B claims $\emptyset$.
- If at $t = 1$ both players deviated, choose any stage-game equilibrium to be played.[2]

In this example, asset 2 serves as a "neutral" or "buffer" zone in period 1, which the players tacitly agree to leave idle. This tacit agreement is enforced by the understanding that if a player claims the asset, then play will revert to the stage-game equilibrium that gives her a continuation payoff of zero. This construction generalises immediately to $|\mathcal{D}| > 3$ and $T > 2$. In the extension, the neutral zone asset is left unclaimed by both players in periods 1 through $T - 1$ inclusive. This is enforced by again specifying that the first player to deviate is "punished" by receiving a further payoff stream of zero for the remainder of the game.

We can use a similar technique to construct a SPE in which contention occurs persistently.

Example 4 (*Persistent Contention*). Let $D = \{1, 2, 3, 4, 5\}$ and $T = 2$. At $t = 1$, the players claim $a_A = \{1, 2, 3\}$ and $a_B = \{3, 4, 5\}$, resulting in contention on asset 3. Play at $t = 2$ depends on the claims made at $t = 1$:

- If at $t = 1$ the players' claims were $a_A = \{1, 2, 3\}$ and $a_B = \{3, 4, 5\}$, then at $t = 2$ player A claims $\{1, 2, 3\}$ and player B claims $\{4, 5\}$.
- If at $t = 1$ player B claims $\{3, 4, 5\}$ and player A makes any claim other than $\{1, 2, 3\}$, then at $t = 2$ player B claims $\{1, 2, 3, 4, 5\}$ and player A claims $\emptyset$.
- If at $t = 1$ player A claims $\{1, 2, 3\}$ and player B makes any claim other than $\{3, 4, 5\}$, then at $t = 2$ player A claims $\{1, 2, 3, 4, 5\}$ and player B claims $\emptyset$.
- If at $t = 1$ both players deviated, choose any stage-game equilibrium to be played.

This construction likewise can be generalised to $T > 2$ by the same method of having any deviation "punished" by having the deviating player's least-favoured stage-game equilibrium implemented for the remainder of the game.

The analysis above shows that, even considering only material payoffs of the game, a wide variety of outcomes are consistent with SPE. For even T, efficient and equal outcomes are possible. However, if D is odd, the SPE supporting efficient and equal outcomes involve playing different stage-game equilibria in different periods. This raises a challenge for players. How can they coordinate on when to shift between the stage-game equilibria as required? The simplest solution is for one player, say player A, to claim $\lfloor \frac{D}{2} \rfloor + 1$ assets for periods $t = 1, \ldots, \frac{T}{2}$, with player B claiming the remaining $\lfloor \frac{D}{2} \rfloor$ assets. For periods $t = \frac{T}{2}, \ldots, T$, the players then reverse the size of their claims. This results in equal payoffs after T periods, but requires trust on the part of player B. There are after all multiple SPE which start out with such an arrangement. In one, A continues claiming $\lfloor \frac{D}{2} \rfloor + 1$ assets in the second half of the game; in another, A intends to change her claim $\lfloor \frac{D}{2} \rfloor$ assets to implement the efficient and equal outcome. By the time the interaction reaches $t = \frac{T}{2}$, player B is therefore exposed to a substantial amount of uncertainty, if she is not confident in player A's intentions. This imbalance can be mitigated by switching off more frequently – for example after each $\frac{T}{4}$ periods – but this is an even more complex strategy to coordinate on.

Therefore, in this game, in principle almost anything can happen in some equilibrium. Contention leading to interactions that resemble wars of attrition are not foreordained, but are possible even under standard preferences — not to mention the possibility of behavioural motivations such as negative reciprocity or spite. These considerations make this game ideally amenable for experimental study, as it is an empirical question how people will process these considerations raised by the theoretical analysis and select from the large set of outcomes which arise even from equilibrium analysis alone.

[2] What occurs in this contingency is not important, as it can only be reached by a joint deviation at $t = 1$ and therefore all that is required for a SPE is that a stage-game equilibrium is played at that history.

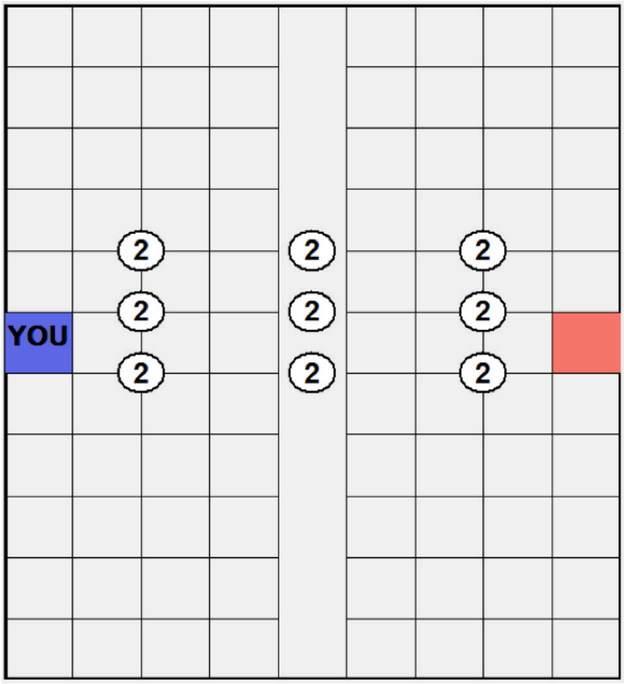


Fig. 1. An example of a "bargaining table". (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

3. Experimental design and procedure

3.1. Representation of the bargaining problem

In representing the bargaining setting, our objective is to provide an environment in which participants can understand at a glance the current situation in the interaction, and in which they can quickly and easily adjust their claims. These criteria call for a graphical representation, which gives the participants a common way to reference each of the distinct assets. We represent the bargaining environment by laying the discs out on a rectangular display based on the "bargaining table" developed by Isoni et al. (2013) for simultaneous-move bargaining and Isoni et al. (2014) for continuous interaction. An example layout is shown in Fig. 1. Participants are represented by a coloured square referred to as their *base*. A player's own base is always shown on the left, coloured blue, and labelled with the word "YOU". The base of the other player is always on the right, and coloured red. Therefore, the two participants in a game saw the same display, only rotated through 180 degrees.

The table is marked with a grid pattern intended to suggest a visual separation of the rectangle into three *zones*. The central column does not have horizontal grid lines drawn; this creates a separation in which there is a zone around each player's base which does have a grid pattern, and a central zone which lacks a grid pattern. We refer to the zone in which Player A's base is located as *Zone A*, the zone in which Player B's base is located as *Zone B*, and the central zone as *Zone C*. Discs are arranged into three columns: one column in the middle of the region around each player, and one column in the central column. In each scenario players bargained over $D = 9$ discs.

It has already been shown by Crawford et al. (2008), Isoni et al. (2014), and Luhan et al. (2017), among others, that the physical layout of objects in this type of bargaining setting influences claims in one-shot games. Because our assets are all identical in value, only their physical location distinguishes them.[3] There is no layout of the discs that a priori can be guaranteed to be "neutral"; each representation might suggest certain discs to be more associated with one player than the other, or conversely might suggest certain discs are more contestable. Because our aim is for the environment to be minimally structured, we do not want to by accident pick a representation whose layout happened to drive the dynamics of bargaining. Therefore, we vary how these discs are distributed among the zones. Write the number of discs in Zone i as D_i, $i \in \{A, B, C\}$. By convention we label players such that $D_A \geq D_B$. There are 20 possible ways to allocate the 9 discs across the zones, such that each player has at least one disc in their zone ($D_B > 0$); we refer to each of these possible allocations as a *scenario*.

[3] This would be true of any graphical representation, not just the bargaining table-based representation we have chosen.

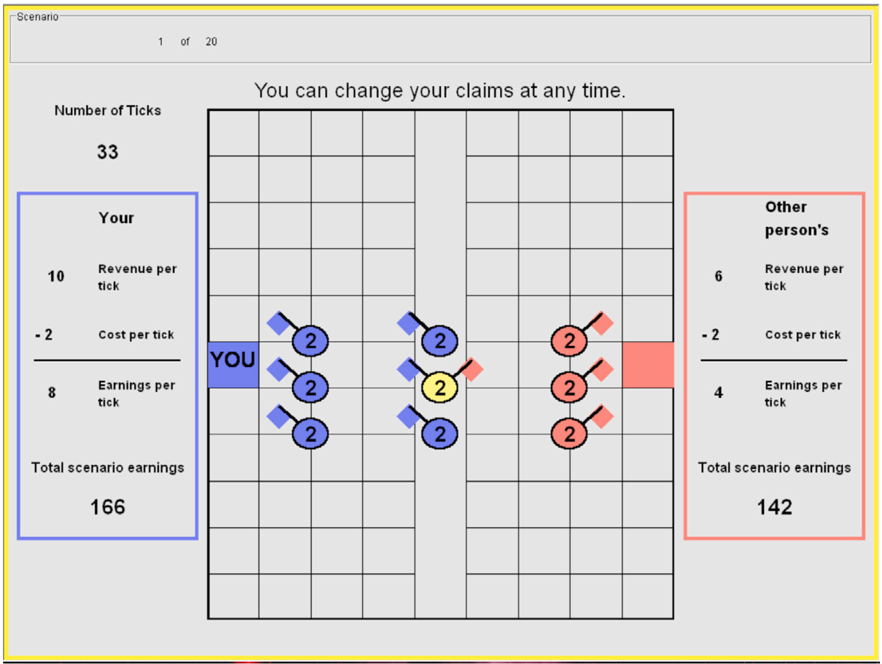


Fig. 2. A bargaining interaction in progress, illustrating the principal features of the bargaining interface. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

3.2. The bargaining process

The experiment was computerised using zTree Fischbacher (2007). We use our rich graphical representation to communicate concisely the current state of the game to the participants. Fig. 2 shows a sample of a typical state of bargaining in the scenario shown in Fig. 1.

The interface provides an easy-to-process representation of both actions - the set of discs each player currently is claiming - and outcomes - how those claims map into the current flow of earnings. Claims are represented by flags, which are coloured to match the claiming player's base, and angled in the direction of that base. Outcomes are represented by the colour of the disc. Discs which are blue are possessed by the participant, while those which are red are possessed by the other player. Discs which are claimed by both players – and therefore in conflict – are coloured yellow. Each scenario began with all discs unclaimed.

Even with the fluidity of the graphical interface, it does take most participants a few seconds to complete initial claims, a physical consideration we abstracted away from in the stylised definition of the game. An alternative initial condition would be to allow players first to choose initial claims simultaneously and independently, and then start the clock. Results from simultaneous-claim studies such as Isoni et al. (2013) and Xue et al. (2021) suggest many pairs would begin in an initial condition with positive amounts of contention due to coordination failure. The contention arising from the initial conditions would be different than that arising during the course of bargaining, as in the latter case a player can see the adaptations the other player is (or is not) making. We chose our initial condition to focus on the latter kind of contention.

The bargaining interactions consisted of $T = 100$ stages; in the experiment we referred to a stage as a *tick*. Ticks occurred approximately once per second.[4] Earnings from each game stage were realised based on the state of claims at the time a tick occurred. At every tick, a participant received 2p for each disc they possessed at a tick, and lost 2p for each disc that was in contention. We represent this in the interface by labelling all discs with the number "2". Participants could toggle their claim on a disc at any time, by clicking on the disc they wanted to claim, or to un-claim. Changes in claims were reflected immediately in the display of flags, but only had earnings consequences once the next tick occurred.

Panels at the sides of the screen displayed the number of ticks which had occurred so far, and the per-tick earnings calculation for both players based on the current state of claims, along with a cumulative running total of earnings for each player from the scenario so far.

[4] There were naturally small delays for network communication and processing, such that an interaction lasted about 101 to 102 seconds overall.

3.3. Eliciting locus of control

To assess participants' locus of control, after the end of all bargaining periods, participants completed the locus of control inventory developed by Rotter (1966). This inventory consists of 13 questions; we include the text of these questions in Appendix. Each question consisted of a pair of related statements; we asked the participant to indicate which of those statements more closely reflected their own views. Within each pair of statements, one would express a view that some outcome was more likely to be the result of luck or external factors, which corresponds to an external locus of control, while the other would take the position that the outcome was under a person's control, corresponding to an internal locus of control. For each participant, we count up the number of questions for which they chose the option corresponding to an external locus of control, resulting in an integer potentially ranging from 0 to 13. We use this as an index of the extent to which the participant has an external (versus internal) locus of control. For brevity, we will refer to this as the participant's *ELOC score*.

3.4. Experimental procedure

We conducted the experiment in the laboratory of the Centre for Behavioural and Experimental Social Science (CBESS) at the University of East Anglia. Participants were recruited from the lab's standing pool of participants, managed using the hRoot system (Bock et al., 2014). Sessions were conducted in February and March 2017.

We conducted four sessions, each with 24 participants, for a total of 96 participants. Within a session, there were 20 periods. Each period within a session used a different one of the 20 possible scenarios; we used a different, randomly-drawn ordering of the scenarios in each session. Within a session, no two participants were matched more than one time.[5]

Sessions lasted from 60 to 75 minutes, including a post-experiment questionnaire comprising the locus of control inventory and the lab's standard demographics battery, from which gender was collected. At the end of the experiment, one of the 20 periods was selected at random to determine participants' realised earnings. Average earnings (including a £9 participation payment) were approximately £16.

4. Research questions

We established in Section 2 that subgame perfect equilibrium rules out very little in the way of possible outcomes: efficiency, inefficiency, concord, and contention are all possible, in many different patterns. This indeterminacy makes this environment an ideal one to explore using an experiment. Because neither theoretical considerations nor previous experimental results in other games offer clear predictions as to what to expect, our experiment aims to address a series of questions about aggregate and individual behaviour, which we now introduce.

4.1. General patterns of bargaining

Because in our game there are subgame perfect equilibria both with and without conflict on the equilibrium path, conflict is not inevitable. This distinguishes our game from, for example, wars of attrition (e.g. Bilodeau et al., 2004; Oprea et al., 2013) in which conflict is the initial state, and the only way out of conflict is for one of the players to concede. Nevertheless, evidence from a variety of experiments in all-pay auctions (Gelder & Kovenock, 2017; Hörisch & Kirchkamp, 2010), rent-seeking contests (Deck & Kimbrough, 2015; Mago et al., 2013) market entry (Phillips & Mason, 1997), and market exit (Oprea et al., 2013), report that participants take actions that lead to greater amounts of conflict than equilibrium baselines predict.

Question 1. *How much contention will occur overall? Will contention be a persistent feature within a bargaining pair, or will it be resolved over the course of a pair? Will contention increase or decrease over the course of the experiment?*

If we were to restrict attention to strategies in the one-period version of the bargaining game, then concord can only be achieved either by one player receiving a higher payoff than another, or by both players leaving a disc completely unclaimed. However, the dynamic nature of our interaction opens the door to turn-taking strategies, in which the players trade off claiming a majority of the discs at different points during the interaction. Turn-taking strategies have been found in previous studies (Lau & Mui, 2008, 2012; Sibly & Tisdell, 2018) as a coordination device in battle-of-the-sexes games (see also Bhaskar, 2000; He & Wu, 2020; Mailath & Samuelson, 2006). More closely related to our own setting, Luhan et al. (2017) also finds evidence in a real-time tacit bargaining game of players achieving outcomes with more equal payoffs via taking turns holding higher value assets.

Question 2. *When concord is achieved, will pairs leave discs unclaimed, agree on an unequal split of the surplus, or will they be able to coordinate successfully on a turn-taking strategy profile?*

Although each of the nine discs in each bargaining interaction is of equal value, any implementation of the game must necessarily distinguish among them such that players have a common understanding of *which* discs each of them is claiming. Our experiment

[5] Full instructions are available as a separate Appendix. As is standard, participants answered a set of control questions prior to the start of the first period.

uses a graphical layout common to both players, which we vary across bargaining interactions such that no participant sees the same scenario more than once. In one-shot tacit bargaining games using the bargaining table layout, the arrangement of discs has been shown to influence claims (Isoni et al., 2013; Xue et al., 2021). Translated to our implementation, discs in Zone A would be more naturally associated with (and therefore claimed by) Player A, those in Zone B would be more naturally associated with Player B. However, the power of layout as a coordination device – or possibly as a source of conflict – should be tempered by the fact that a player gets continuously-updated information on the current claims of the other player. We also note that our matching protocol undercuts the possibility of the emergence of log-rolling conventions, in which a player accepts a lower share of the earnings from the current bargaining interaction in anticipation of the roles being reversed in a future interaction.

Question 3. *Will the graphical layout of the discs influence claims and outcomes?*

4.2. Individual approaches and outcomes

The interactive nature of the bargaining game, and the wide range of strategies which can be optimal against some strategy of the other player, opens the door for individual differences in approaches to bargaining to show themselves.

Question 4. *Are there differences in how successful participants are at bargaining? Do some participants manage to possess discs more often than others? Do participants differ in the amount of contention that occurs in their interactions?*

Relatedly, we can ask questions about whether any observable characteristics of participants predict the outcome of the bargaining interactions they are part of. We will look at two such characteristics, gender and locus of control.

As outlined in the introduction, results across many classes of experimental games and interactions suggest that in many environments there are systematic differences in behaviour and outcomes between genders. However, the results from different environments do not paint a clear pattern. In particular, in the case of experiments involving conflict, results on the role of gender are mixed (e.g. Cadsby et al., 2013; Chowdhury et al., 2016; Eagly & Crowley, 1986).

Question 5. *Will the efficiency and amount of contention observed in bargaining pairs differ by the gender identities of the participants in the pair?*

Previous studies on bargaining interactions (e.g. Bobbitt, 1967; Wall, 1977) have found evidence that people with an internal locus of control (LOC) behave more competitively than those with an external LOC under a cooperative bargaining environment. When the environment is more competitive, the finding is reversed, with people with an internal LOC behaving more cooperatively.

Question 6. *Do pairs in which participants both have an external locus of control incur different (higher) costs of conflict than those in which participants have an internal locus of control?*

5. Results

5.1. General patterns of bargaining

We begin with a high-level overview of earnings. Our dataset consists of 958 scenario-pairs.[6] Fig. 3 presents a histogram describing the distribution of the total earnings per scenario-pair across all scenario-pair observations. Earnings in a scenario-pair could range from −3600 (conflict on all discs at all ticks) to +1800 (each disc claimed by exactly one of the two players at each tick). We observe immediately that many scenario-pairs come very close to attaining full extraction of the potential surplus. The interquartile range for total earnings by scenario-pair is $[1260, 1770]$, meaning that 25% of pairs were within 30p of full theoretical efficiency. The median scenario-pair earnings was 1674, and the mean 1397, reflecting the long tail of lower earnings; 4% of the scenario-pairs actually wound up with negative net earnings at the end of the interaction. Recall that we paid one randomly-selected period, and that participants were given a participation payment of £9, which was used to offset any losses realised in the selected period. Therefore losses up to £9 by a participant in the selected period would be realised in their final earnings, while losses above that would not drive down total experiment earnings further. This earnings distribution shows that the participants' limited liability in the event of massive contention is not an important factor.

Because the interaction is so open-ended and so many approaches to bargaining are consistent with best-responding, we expect that participants might learn and adjust with experience on how to achieve concord and avoid contention. In Fig. 4, we show how the cumulative distribution of costs of contention evolves over time. In the graph, the bottom region, shaded the lightest, is the proportion of pairs which had exactly zero contention. Each successive contour line represents the proportion of pairs with costs up to 25, up to 50, and so on in steps of 25. The top region, shaded in black, are pairs with costs above 350. What is particularly remarkable is the observation that in the first period, 23 out of 48 (48%) pairs had *exactly zero costs of contention*. This proportion drops rapidly in the second period, and further generally declines throughout the experiment. To quantify this observation, including all periods there are 171 instances out of the 958 scenario-pairs with zero costs; the probability of 23 or more of these instances

[6] We have 20 scenarios, and for each we have 48 pairs. The data recorded for two scenario-pairs is internally inconsistent; we omit these from the analysis.

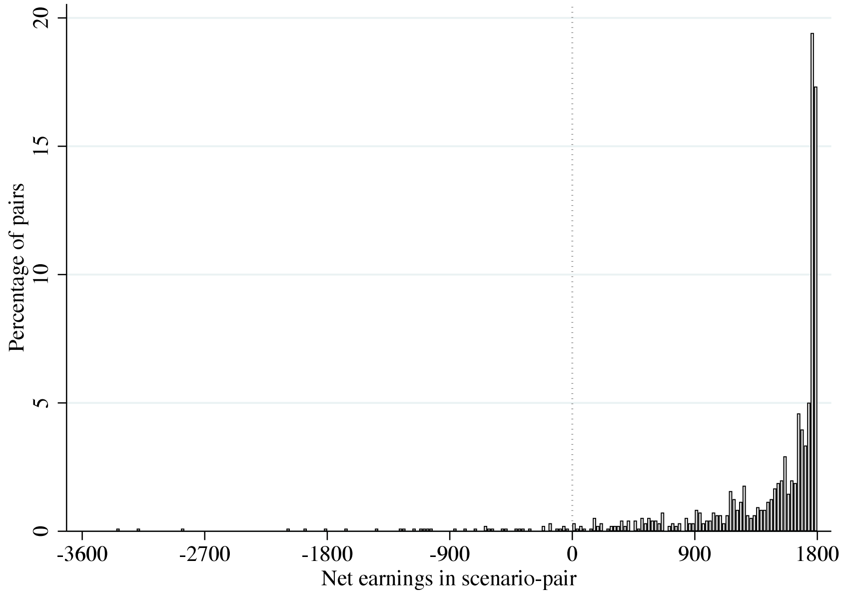


Fig. 3. Distribution of total earnings per scenario-pair.

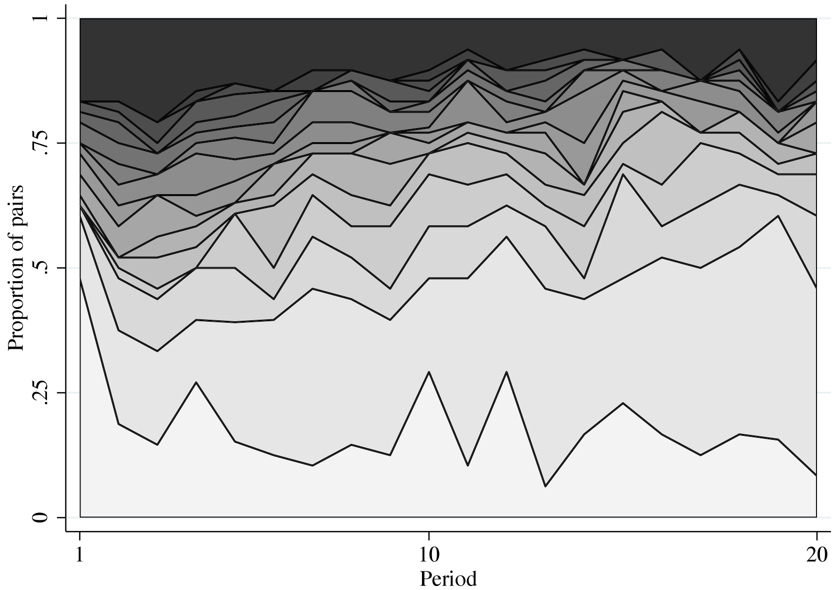


Fig. 4. Cumulative distribution of costs of contention, by period. The lowest region are pairs with exactly zero contention. Each successive region plots the proportion of pairs in increments of 25p of costs. The top region represents pairs with costs above 350.

would happen in a given 48 pairs by random chance is less than 10^{-6}. Meanwhile, the proportion of pairs with costs above zero but below 25 increases; above a cost of 25, the proportions do not change much across the experiment. Taken together, we observe that participants are initially reluctant to engage in contention, but quickly recognise that effective bargaining requires a willingness to incur small costs. This "convergence from below" may be influenced in part by our choice of initial condition that guaranteed interactions started in a situation of no contention; this alone however would not explain the large movement from period 1 to period 2. There remains a persistent proportion of pairs with high costs of contention throughout all periods.

Result 1. *Approximately one-third of pairs overall achieve high efficiency outcomes. Participants learn quickly to use small amounts of contention to drive bargaining without suffering much inefficiency, while high-contention pairs occur throughout the experiment.*

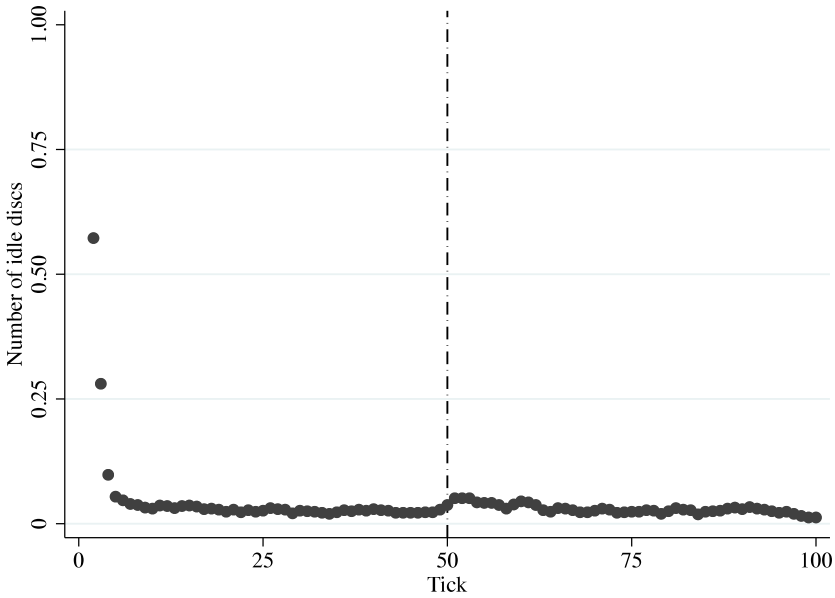


Fig. 5. Number of discs left idle, by tick, aggregating across all scenario-pairs.

The overall levels of efficiency would appear to be consistent with sustained contention, rather than leaving discs idle to avoid contention. This is indeed the case. Fig. 5 plots the number of discs left idle as a function of the tick number, aggregated across all scenario-pairs. From this we can see it takes up to 2 to 3 seconds for participants to complete selecting their initial claims. After that initial selection, the number of idle discs is negligible. From this we see that some of the inefficiency in those scenario-pairs who attained joint earnings close to 1800 did arise simply because of the time required to carry out the mechanics of setting up initial claims. However, idle discs are not a substantial contributor to inefficiency during the bulk of the interactions, and "neutral zone" techniques were at most rarely used to forestall potential contention. We therefore focus the remainder of the analysis on efficiency, and how it is affected by the structure of contention.

We next look at how the size of contention changes throughout the progress of a given bargaining pair. At each tick t, we tabulate the proportion of pairs who, at t, have contention on zero discs (i.e., concord), one disc, or two or more discs. Fig. 6 plots these proportions. This figure reveals two interesting observations. First, the proportion of pairs in concord increases over time, with one important exception, which occurs around tick 50. Just after tick 50, there is a drop in the proportion of pairs in concord, with a corresponding rise in the proportion of pairs in contention over exactly one disc. After this jump, the proportion of pairs in concord resumes its rise, but from this new lower base level. Second, the trajectory of the lines for contention on zero discs and one disc closely mirror one another. The trajectory for the proportion of pairs with contention on multiple discs is generally flat after the first few ticks. Taken together, these observations suggest that initial contention over a single disc is resolvable roughly half of the time, while contention over two or more discs is much more intractable.

The increase in contention after tick 50 is driven principally by pairs in which the player who has been unfavoured in the first half of the game negotiating an implementation of a turn-taking strategy. To look for evidence of turn-taking approaches, for each pair, we compute the proportion of ticks at which $\#a_A > \#a_B$, and the proportion of ticks at which $\#a_B > \#a_A$. A strategy profile which exhibits perfect turn-taking these proportions would both be exactly one-half.

In Fig. 7 we look at the sample of 442 scenario-pairs in which there was no contention for more than 90% of the ticks; in this bubbleplot the size of the bubble at a coordinate is proportional to the number of pairs represented. This plot shows that pairs achieve concord overwhelmingly by one of two routes. The more common arrangement is that either Player A or Player B claims a majority of the discs at almost all ticks. In 27.4% of the 442 scenario-pairs, Player A claims a majority in over 95% of the ticks, while in a further 19.2%, Player B claims a majority in over 95% of the ticks. Turn-taking strategies are represented in the region in which both of the proportions are close to one-half. We define a turn-taking strategy profile as one in which both Player A and Player B each claim a majority of the discs in at least 43% of the (no-contention) ticks. 30.3% of scenario-pairs qualify as turn-takers under this criterion. Recall that around tick 50, the proportion of pairs with no contention drops by about 10%. This increase in contention is the result of pairs adopting turn-taking strategy profiles negotiating a swap-over at the halfway point. We looked by hand for more complex turn-taking arrangements. We found just a handful of instances in which a pair successfully swapped over after each 25 ticks. The simplicity and focality of swapping over halfway outweighs the strategic uncertainty faced by the player who is unfavoured by the claims agreed in the first half.

Result 2. *Concord is achieved by a mix of turn-taking approaches and pairs who agree to let one player claim a majority of the discs throughout. Discs are very rarely left idle for extended periods of time.*

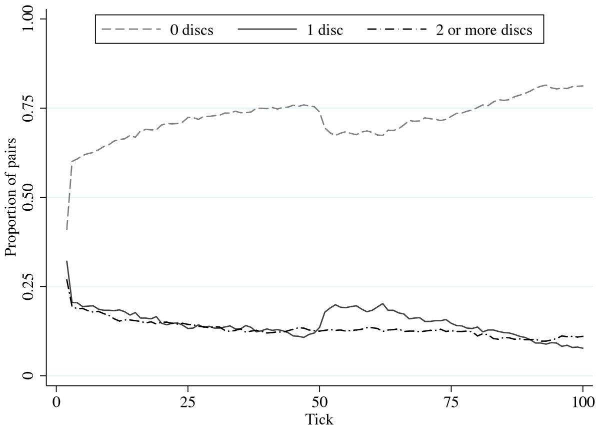


Fig. 6. Proportion of pairs by amount of contention, by tick number.

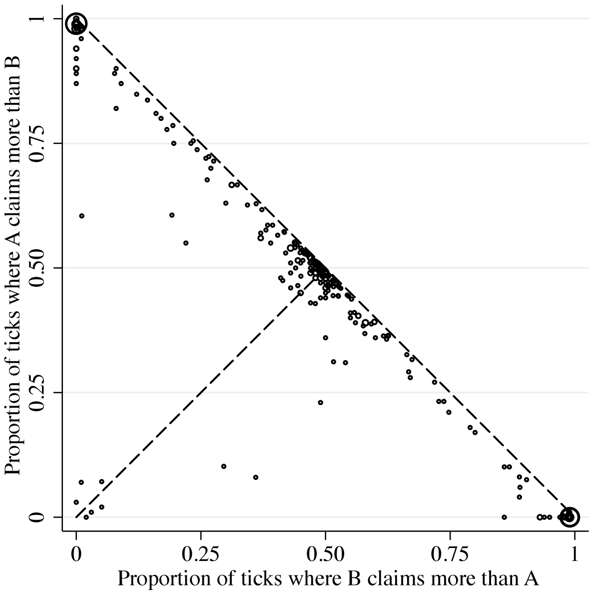


Fig. 7. Patterns of action claims across a bargaining pair. Each pair is located on the graph by the proportion of ticks at which A claimed more discs than B (vertical axis), and the proportion of ticks at which B claimed more discs than A (horizontal axis). The size of the bubble at each coordinate is the number of pairs at that coordinate.

We look next at whether the layout of the discs affects the amount of contention. We report per-scenario scatterplots in Fig. 8. We represent the payoff outcomes as a pair $(u_A + u_B, u_A - u_B)$, in which the first coordinate captures the (in)efficiency of the outcome, and the second the distribution of payoffs between the players. The feasible outcomes form a triangle, with the efficient outcomes along the edge at the top, and the worst outcome (contention on all discs at all ticks) corresponding to the vertex at the bottom. To each triangle we add two reference lines: a vertical line which is the locus of outcomes in which both participants earn the same amount, and a horizontal line which is the local at which the total net payoff is zero. The outcome of each pair is plotted as a point.

This representation shows at a glance the general patterns of bargaining outcomes. From this we can make some general qualitative observations. In all scenarios, pairs do cluster near the efficient and equal outcome. However, the distribution of points does not appear to differ systematically across scenarios as a function of D_C or $D_A - D_B$. In scenarios with $D_A > D_B$, outcomes are roughly equally likely to fall to the left of the equal-earnings reference line (meaning player A earned more), or to the right (meaning player B earned more). This suggests that whatever influence the graphical layout of the discs might have on bargaining is at most a minor consideration relative to the approaches to bargaining the participants take.

Visual inspection of the per-scenario earnings outcomes diagrams in Fig. 8 suggests that the structure of the scenario does not affect outcomes greatly. As a more precise analysis, because previous studies have suggested that (a)symmetry in the framing of a

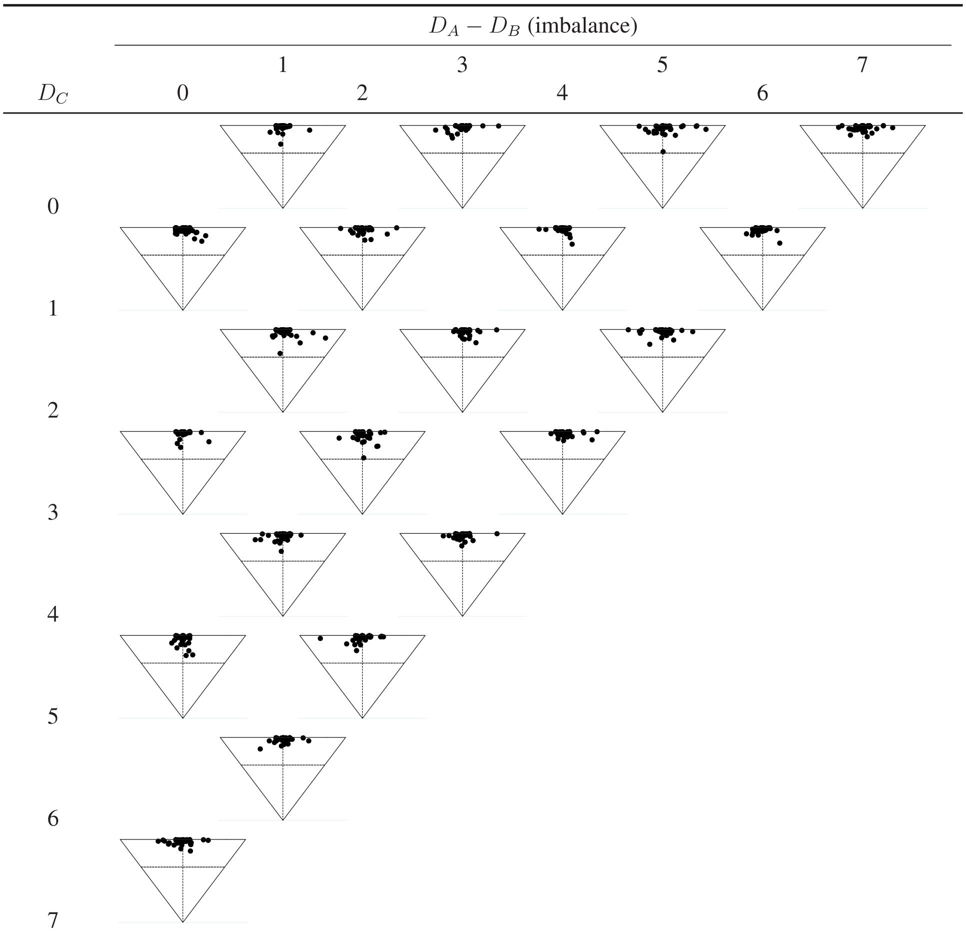


Fig. 8. Pairwise earnings outcomes, by scenario. Each triangle represents the set of feasible earnings distributions in the labelled scenario, and each dot the outcome of one pair in that scenario.

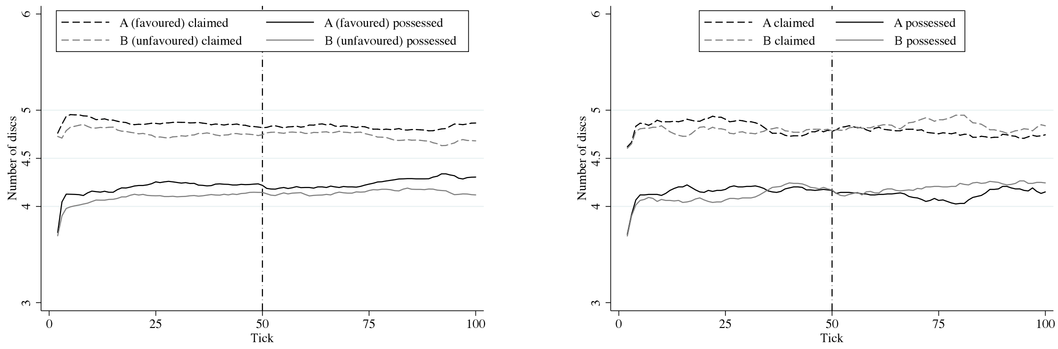
Table 1
Summary statistics for average value of discs claimed and total cost of contention per scenario, aggregated by scenario symmetry.

Scenarios	Claims		
	Player A	Player B	Contention
Asymmetric	959.9	939.5	124.4
Symmetric	950.5	953.1	130.9

bargaining environment can influence outcomes, we group scenarios into symmetric ($D_A - D_B = 0$) and asymmetric categories. In Table 1 we report the average for the total value of discs claimed by each of Player A and Player B, and the total cost of contention, by scenario, grouped by whether the scenario was symmetric. In symmetric scenarios, where the labels of Players A and B are arbitrary, the value of discs claimed by the two roles is similar. In asymmetric scenarios, Player A, who by our labelling convention is the player who had more discs in the zone closer to their base, claims about 20.4 more discs than Player B. This is not a large effect; recall that each disc is worth 2, and we are aggregating across 100 ticks, so a difference of 20 would work out to a difference of 0.1 discs claimed per tick.

A way to visualise this is by looking at claims as a function of the tick number, which we do in Fig. 9. The difference in claims is persistent, but small in magnitude, across all 100 ticks in asymmetric scenarios, while in symmetric scenarios the claims of Players A and B are similar throughout.

Turning to the costs of contention, in asymmetric scenarios the loss per player due to contention is about 6.5 lower than in symmetric scenarios. Again, this is a minuscule amount, corresponding to a difference of about 0.0325 discs in contention per tick. Given the previous analysis showing that few discs are idle, the amount of contention at any given tick is well-approximated by the



(a) Asymmetric scenarios

(b) Symmetric scenarios

Fig. 9. Discs claimed and possessed by players A and B, by tick, averaged over all pairs.

Table 2
Individual participant performance measures. The first group of columns are summary statistics across the 96 participants. The second group are data for test of whether the standard deviation of the measure is greater than would be expected by chance, based on a Monte Carlo permutation test.

Measure	Data				Permutation test on SD		
	N	Median	Mean	SD	Expected	Interquartile	CDF
Income	96	822.4	824.2	39.9	36.4	(34.7,38.0)	.927
Contention	96	102.9	126.1	93.4	49.5	(47.5,51.5)	>.999
Payoffs	96	731.6	698.2	101.4	78.8	(75.4,82.1)	>.999

difference in Fig. 9 between the lines showing the claims of the players and the number of discs each possesses; these are roughly constant across the 100 ticks.

These differences are small in economic magnitude, and further do not rise to the level of statistical significance in our data. To test whether there is a difference between symmetric and asymmetric scenarios, we conduct permutation tests, in which we assign at random which 4 scenarios are labelled as symmetric. Based on 10,000 such permutations, we find no (a)symmetry effect on the difference in claims between Players A and B ($p = 0.23$), nor in cost of contention ($p = 0.67$, two-sided alternative for both tests).

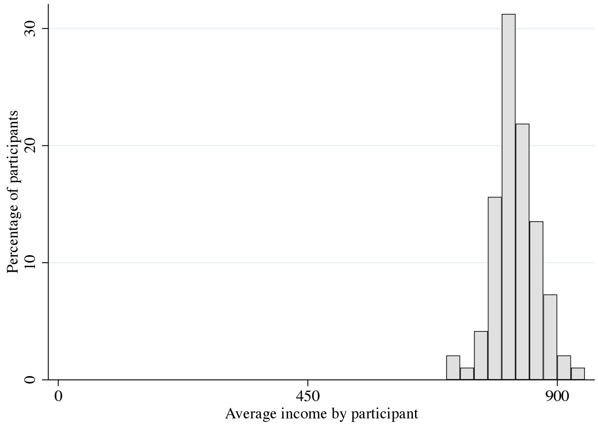
Result 3. *Even among asymmetric scenarios, there is no economically nor statistically significant difference between the two player roles in the number of discs claimed. There is no difference in costs of contention between symmetric and asymmetric scenarios.*

5.2. Individual approaches and outcomes

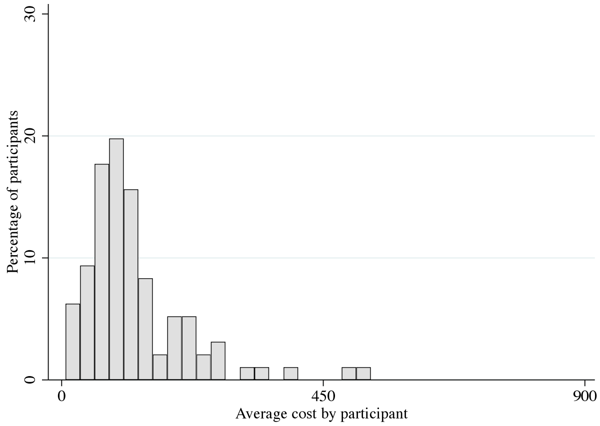
We turn now to examining heterogeneity in individual bargaining performance. As a starting point, we compute three overall performance metrics for each participant, averaged over the 20 scenarios: their average income from discs possessed, their average cost of contention, and their average earnings. We present summary statistics on the distribution of these in Table 2, and plot histograms of their distributions in Fig. 10. The distribution of payoffs across participants is skewed; this skewness comes principally from the shape of the distribution of costs of contention. From a visual inspection, it appears that participants do vary in their ability to earn money from bargaining, and this variation is explained by their (in)ability to avoid contention, rather than their ability to claim and hold larger numbers of discs over time.

To make this observation more precise, we conduct hypothesis tests on the standard deviation of these measures based on permutation tests. Specifically for the tests on the participant performance measures, for each measure we create 10,000 copies of the dataset, in which, in each session and period, we shuffle randomly the participant identifiers, and compute the standard deviation of the participant performance measure for each copy of the dataset. We then compare our observed standard deviation against this distribution. The data for carrying out these tests is summarised in the second group of columns in Table 2. We find that the standard deviations we observe for costs of contention and overall payoff are far larger than would be expected by random chance; indeed, our observed values are greater than *any* value in our simulated datasets. This allows us to reject the null hypothesis of no variability in bargaining approaches across the participants at any standard level of significance. The standard deviation of income from discs possessed is likewise above what is expected, but not far enough into the tail to reject a null hypothesis of no individual variation against the two-sided alternative at standard levels.

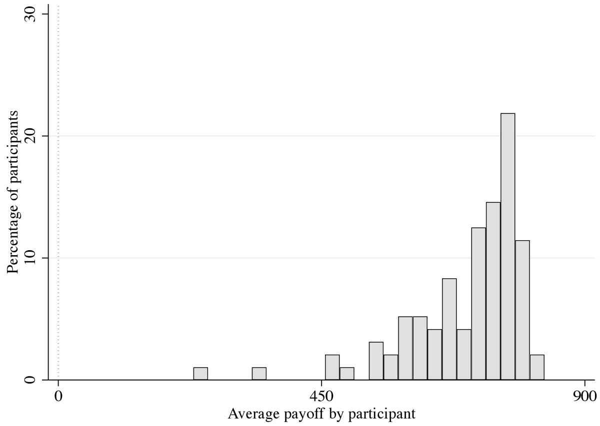
Result 4. *Participants do vary significantly in their success in bargaining, as measured by their average earnings across scenarios. This occurs principally because participants vary in the costs of contention they incur.*



(a) Income



(b) Contention



(c) Payoffs

Fig. 10. Distributions of participant performance measures, averaged across the 20 scenarios.

Table 3 breaks out the distributions of earnings and costs of contention by the two demographics of interest: gender and locus of control. The outcomes of females are more dispersed than those of males, by both measures; females were both more likely to have

Table 3
Distribution of bargaining performance per scenario, by demographic group. Note: Two participants declined to disclose their gender.

(a) Payoffs

Group	N	Mean	SD	Five-number summary				
				Min	25th	Median	75th	Max
Male	46	708.3	77.1	456.0	674.6	726.5	766.3	796.2
Female	48	689.3	120.7	231.5	628.9	740.3	766.9	821.3
Internal LOC	31	684.4	99.1	456.0	645.5	716.2	749.7	821.3
Neutral LOC	31	705.3	103.4	338.7	655.2	744.5	784.1	811.9
External LOC	34	704.2	103.3	231.4	674.6	742.6	762.4	803.6

(b) Contention

Group	N	Mean	SD	Five-number summary				
				Min	25th	Median	75th	Max
Male	46	118.2	67.1	32.1	68.8	106.6	146.1	339.0
Female	48	132.4	114.3	6.7	59.4	91.7	188.3	516.2
Internal LOC	31	146.8	92.3	23.3	86.2	119.3	202.9	401.3
Neutral LOC	31	114.3	98.9	6.7	60.8	98.1	150.2	516.2
External LOC	34	117.9	88.8	19.8	61.6	92.0	146.1	488.0

Table 4
Tobit regressions modelling cost of contention. The unit of observation is one scenario-pair. Standard errors are clustered at the session level.

	(1)	(2)	(3)	(4)
Male–Female	7.59		−11.27	−12.56
	(0.07)		(−0.11)	(−0.12)
Male–Male	−88.30		−120.28	−120.94
	(−0.66)		(−1.04)	(−1.04)
Sum of ELOC scores		−13.46	−15.72*	−15.75*
		(−1.36)	(−1.99)	(−2.00)
Difference of ELOC scores		−13.47***	−13.66***	−13.29***
		(−4.45)	(−4.02)	(−3.92)
Period				−5.88***
				(−4.81)
Constant	86.17	114.35	126.42	220.17
	(0.90)	(1.52)	(1.29)	(1.81)
Scenario controls	Yes	Yes	Yes	Yes
Session controls	Yes	Yes	Yes	Yes
Observations	919	919	919	919

t statistics in parentheses
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

very low and very high costs of contention. Nevertheless, the distribution of relative rankings by both measures are not different (MWW test on earnings, $p = 0.98$; on contention, $p = 0.58$).

For locus of control, we divide our participants into three groups based on their ELOC score. For the 13 items on the locus of control inventory, we obtain a value of Cronbach's α of 0.54; see Appendix for further detail. This value of α is below-standard internal consistency, and further is lower than typically reported for versions of Rotter's scale. We discuss this in the context of our experiment and results further in Section 6.

We classify participants with an ELOC score of 8 or more (out of a possible 13) as having an external locus of control, and those with an ELOC score of 5 or less as having an internal locus of control; the remaining participants are classified as having a neutral locus of control. This divides the participants into three groups of almost equal size (31 internal, 31 neutral, and 34 external). The external locus of control group has higher mean payoffs and lower mean costs of contention than the internal locus of control group, but these are not significant (MWW test on earnings, $p = 0.28$; on contention, $p = 0.095$).

However, an essential feature of our bargaining games is that they are interactive, and therefore the characteristics of the two participants in a given scenario-pair may interact to shape the outcome. In Table 4 we present the results of Tobit models for the cost of contention for a scenario-pair as a function of the gender composition and locus of control, including controls for scenario and session and, in the grand model (4), period as a time trend. The sample for this estimation omits the 40 scenario-pairs in which one of the participants did not disclose their gender. In the 919 scenario-pairs in which both participants disclosed their gender, 169 had exactly zero cost of conflict. We note that, in our grand model specification (4), we cannot reject the null hypothesis that all of the scenario indicators are zero ($p = .75$). This can be interpreted as providing additional support for Result 3.

For gender, we include indicator variables specifying whether the pair consisted of two males (*Male–Male*) or was of mixed gender (*Male–Female*). For locus of control, we include two measures, the sum of the ELOC scores of the two participants in the scenario-pair, and the (absolute value of) the difference of the ELOC scores.

For gender, we find large point estimates for the effect of all-male pairs against the baseline of all-female pairs, as well as the difference between all-male pairs and mixed-gender pairs: all-male pairs on average have much less conflict than other pair types. However, these are not statistically significant.

There is evidence, however, that the interaction of locus of control measures does predict the cost of contention. The more different the locus of control measures, the lower the cost of contention: this is significant at $p < .001$ in all models where this characteristic is included. In addition, the significant ($p < .05$) coefficient on the sum of ELOC scores indicates that, in general, the more the participants tend towards external locus of control, the less contention occurs.

Result 5. *We do not find statistically significant gender effects in the composition of pairs. There is less contention in pairs in which the two participants have different locus of control orientations, and in pairs in which the participants' locus of control orientation is more external.*

6. Conclusion

We report the results of an experiment in which participants bargain over valuable assets which yield streams of income while the negotiations take place. The environment is sufficiently open-ended that most bargaining behaviours are consistent in principle with best responses to some conjectured strategy of the other player. The rich interaction that is possible in this environment leaves it up to the participants what they will make of the interaction: they can get mired in intractable conflicts that last throughout the interaction, or they can find a way to extract the available surplus efficiently. Rather than imposing a rigid extensive game form on the interaction, the experimental design reveals something of the process through which concord is or is not achieved.

We find that concord and contention co-exist throughout the experiment. Interestingly, even participants who are inclined towards finding a cooperative solution to extract most of the surplus learn quickly the usefulness of small amounts of contention. Some of this low-level contention is associated with the negotiation of turn-taking strategies that allow pairs to approximate efficient and equal outcomes.

In order to study unstructured bargaining, we want to place as few restrictions as possible on the players. Among the desiderata for an environment to be unstructured would be that the interaction "feels continuous". However, formally characterising equilibria in continuous time is fraught with technical challenges; see for example Simon and Stinchcombe (1989). One solution is to retain discrete time but imagine that time intervals are relatively short; this is the approach we adopt in Section 2. Having discrete time intervals has the advantage, in a laboratory setting, that we can implement exactly the game that the theory describes, in our case, realising payoffs only at discrete moments in time. Equally, though, there are limits to human reaction and processing time; making time intervals short enough that the interaction feels "continuous" also means arbitrary adjustments of strategies by a player in two successive time intervals is difficult, no matter how fluid the choice interface may be. The flexibility our players in our theoretical analysis have, then, is greater than human players could implement. In showing the examples of subgame-perfect equilibria with idle assets or with persistent contention, what is important is the mechanism of continuation play by which these are sustained; as long as the remaining number of time intervals is sufficiently large, a delay of a few intervals in implementing the prescribed continuation would not affect the basic idea. See Calford and Oprea (2017) for an experiment which considers the differences in predictions between continuous-time and discrete-time games, and the role of inertia (delayed reaction speeds) in shaping outcomes in a timing game.

Among dynamic unstructured bargaining experiments, we are the first to consider a cost of contention which is tied specifically to conflict over specific assets. We note, however, that the example equilibria we exhibit in our analysis remain equilibria even if conflict is not costly. However, the equilibria would no longer be strict, in that a player could add a claim without cost on an asset currently claimed by the other player. Conversely, in a setting without cost of conflict, a player has no positive (direct) incentive to release a claim on an asset. The presence of costly contention makes more interesting the frequent use we observe of small amounts of contention strategically to shape the bargaining process.

We observe turn-taking emerge as a solution to the tension induced by an odd number of assets. In our design, participants do not encounter each other more than once, and never do they see the same layout of discs on the bargaining table. These features are intended to make the emergence of conventions more difficult, and so the successful implementation of turn-taking is implemented entirely through the dynamics of claims within a pair. Turn-taking is necessitated in our setting by the assumption that assets are indivisible and therefore direct sharing is ruled out. Whether turn-taking is a viable solution in applications such as the one we open the paper with depends on the situation. Certainly, children do exhibit turn-taking behaviour. Sometimes, even political entities do. The current (as of this writing) governing coalition in the Republic of Ireland agreed at its formation to swap the office of Taoiseach between representatives of different parties at an agreed date. Every six months, Spain and France alternate the administration of (uninhabited) Pheasant Island.

The mechanics of turn-taking in our data are generally driven by the player who received lower earnings in the first half of the interaction making an additional claim at the start of the second half. A similar phenomenon, in which the disadvantaged player initiates a turn-taking transition, is observed in a continuous-time battle of the sexes game by Zhao (2021). Within an explicit bargaining context, Hyndman (2023) find that in a two-stage bargaining game, participants who were disadvantaged in the first stage expect, and generally wind up receiving, compensation in the second stage. In his setting, the second stage operates in two steps, with an initial claims stage, followed by a concessions stage. He finds many bargaining pairs have conflict after the initial claims stage because the previously advantaged player proposes the status quo, while the disadvantaged player expects compensation. This parallels the structure of the interaction we observe in many of the turn-taking pairs, which arises endogenously in our less-structured environment. Taken together, all these results suggest that while fair division is a widely accepted norm for outcomes, nevertheless it is up to the player who is disadvantaged initially to initiate the "ask".

We do find that participants differ systematically in their approaches to the game. In particular, participants differ in the amount of contention they enter into; however, a greater willingness to engage in contention does not in general lead to generating more income from possessing assets. Gender does not significantly explain variation across participants. Our design does not make gender salient, and opting-out of bargaining entirely is not possible. Given these features of our setting, the lack of systematic gender effects would be consistent with recent results mentioned in the introduction.

We obtain stronger evidence on the effect of locus of control. In particular, we find that pairs in which participants have different locus of control orientations experience less contention. This would be consistent with previous results suggesting that people with internal locus of control adapt themselves to the approach of the other player. We also find, however, that a general tendency towards external locus of control in a pair likewise leads to less contention. This appears to be a new finding. A priori it was not clear what to expect in pairs in which both participants had an external locus of control; certainly one theory would be that these pairs would be at risk of significant conflict, because both would be inclined to accept the contention passively by thinking, "them's the breaks", whereas participants with internal locus of control would look for a way to resolve the contention profitably. However, it could equally be that when two participants with internal locus of control bargain, both believe they can come out on top, and this leads to higher contention in these pairs. While our design provides some rich data on bargaining interaction over time, we do not observe the perceptions or intentions of the participants that motivate their bargaining positions.

However, our results on locus of control should be interpreted with some caution given the value of Cronbach's α for our inventory, which indicates internal consistency which is both below general standards, and specifically lower than the internal consistency commonly found for variants of Rotter's scale. Most studies which link locus of control with economic behaviours leverage existing data on the decisions and outcomes of the participants. Our study is one of the few which has combined a version of Rotter's scale in the context of an experiment with incentivised choices. For example, the evidence on the link between locus of control and bargaining behaviour provided by Wall (1977) used non-incentivised interactions, where participants interacted with experimenters who followed a script. In contrast, our participants are familiar with the typical structure of experiments in economics, in which the incentivised choices are the main event. The juxtaposition of incentivised and non-incentivised choices may have unanticipated effects. Because the locus of control scale is by its nature not incentivised, responding to the inventory may seem less important to participants, who may as a result pay less attention to them than they would have had they been administered in a standalone way, leading to noisier responses and therefore lowering internal consistency as a result. Further, administering the inventory in the context of incentivised, interactive choice may change the interpretation or salience among the items. The empirical evidence on the link between locus of control and economic behaviour and outcomes suggests that integrating locus of control in incentivised experiments is a valuable line of research, and our results on the relationship between locus of control and bargaining outcomes support this view. However, further confirmation as to whether our measured consistency of the locus of control scale is an outlier, or whether there is an interaction effect which requires consideration of the best way to design a protocol to combine incentivised and non-incentivised choice.

Appendix. Locus of control inventory

A.1. Text of questions

Participants were given 13 pairs of statements, and, for each pair, were asked to indicate which statement they agreed with more. In each pair, one statement was intended to be interpretable as being associated with an external locus of control, while the other with an internal locus of control. In the listing below, we indicate these with the labels E and I, respectively.

1. E Many of the unhappy things in people's lives are partly due to bad luck.
   I People's misfortunes result from the mistakes they make.
2. I One of the major reasons why we have wars is because people do not take enough interest in politics.
   E There will always be wars, no matter how hard people try to prevent them.
3. E In the long run, people get the respect they deserve in this world.
   I Unfortunately, an individual's worth often passes unrecognised no matter how hard he tries.
4. I The idea that teachers are unfair to students is nonsense.
   E Most students do not realise the extent to which their grades are influenced by accidental happenings.
5. E Without the right breaks, one cannot be an effective leader.
   I Capable people who fail to became leaders have not taken advantage of their opportunities.
6. E No matter how hard you try, some people just do not like you.
   I People who cannot get others to like them do not understand how to get along with others.
7. E I have often found that what is going to happen will happen.
   I Trusting to fate has never turned out as well for me as making a decision to take a definite course of action.
8. I In the case of the well prepared student, there is rarely, if ever, such a thing as an unfair test.

E Many times exam questions tend to be so unrelated to course work that studying is really useless.

9. I Becoming a success is a matter of hard work; luck has little or nothing to do with it.
E Getting a good job depends mainly on being in the right place at the right time.

10. I The average citizen can have an influence in government decisions.
E This world is run by the few people in power, and there is not much the little guy can do about it.

11. I When I make plans, I am almost certain that I can make them work.
E It is not always wise to plan too far ahead because many things turn out to be a matter of luck anyway.

12. I In my case, getting what I want has little or nothing to do with luck.
E Many times we might just as well decide what to do by flipping a coin.

13. I What happens to me is my own doing.
E Sometimes I feel that I do not have enough control over the direction my life is taking.

A.2. Cronbach's α analysis

We encoded the responses to the inventory as 1 if the participant chose the response we labelled E, and 0 for the response labelled I. The overall Cronbach's α for the 13 questions is .540. All questions entered into the calculation of α with the same sign. Below we report the by-question analysis reporting the correlation of each question with the overall ELOC measure, the correlation with the other questions, and the Cronbach's α resulting if that question were dropped from the ELOC score.

Question	Fraction of *E*	Correlation with overall	Correlation with others	α if item removed
1	.49	.217	.010	.566
2	.65	.291	.096	.545
3	.64	.447	.267	.506
4	.64	.429	.246	.511
5	.53	.422	.231	.514
6	.80	.242	.079	.545
7	.60	.244	.042	.558
8	.23	.308	.139	.534
9	.48	.525	.350	.484
10	.55	.396	.202	.521
11	.42	.528	.356	.483
12	.26	.415	.248	.511
13	.31	.608	.464	.459

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