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Focal points and payoff information in tacit bargaining

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ABSTRACT

Schelling proposed that payoff-irrelevant cues can affect the outcome of tacit bargaining games by creating focal points. Tests of this hypothesis have found that conflicts of interest between players inhibit focal-point reasoning. We investigate experimentally whether this effect is reduced if players have imperfect information about each other's payoffs. When players know only their own payoffs, they fail to ignore this information even though it cannot assist coordination; the effects of payoff-irrelevant cues on coordination success are small. When no exact information about payoffs is provided, payoff-irrelevant cues are more helpful, but not as much as when conflict is absent.

In his famous book *The Strategy of Conflict*, Schelling (1960) develops a theory of *focal-point reasoning* in games with multiple Nash equilibria. This form of reasoning is fundamentally different from the best-response reasoning that is standard in game-theoretic analysis. The essential idea is that players concert their mutual expectations on one equilibrium – the *focal point* – by appealing to their shared knowledge about salient properties of the game. In some cases, the focal point is salient because it payoff-dominates other equilibria, but salience often derives from payoff-irrelevant features of the way strategies are labelled.

It is now empirically well established that real players successfully coordinate on payoff-dominant equilibria in coordination games in which there are no conflicts of interest (e.g. Bacharach, 2006; Bardsley et al., 2010) and that label-salient focal points are very effective in Pure Coordination games, in which all equilibria have the same payoffs for all players (e.g. Schelling, 1960; Mehta et al., 1994a, 1994b; Bacharach and Bernasconi, 1997; Crawford et al., 2008; Bardsley et al., 2010; Parravano and Poulsen, 2015). Significantly, however, these cases of successful coordination occur in games in which the players have a shared ranking of the equilibria. Schelling argues that rational players would use the same kind of reasoning in what he calls situations of *tacit bargaining*, that is, games in which two players have a common interest in coordinating their strategies, but their interests conflict over how coordination should be achieved, and communication is not possible.

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He uses the term 'tacit bargaining' to signify that games of this kind can be useful reduced-form models of real-world bargaining situations, including situations in which communication *is* possible.[1]

The simplest examples of tacit bargaining games have the 2×2 Battle of the Sexes structure. Like Pure Coordination games, these games are symmetrical with respect to players and strategies, and so classical game theory cannot distinguish between the pure-strategy equilibria (e.g. Harsanyi and Selten, 1988); the difference is that the players have conflicting rankings of those equilibria.[2] Just as in Pure Coordination games, the players may have common knowledge of salient labelling properties that would allow them to concert their expectations on a focal point. Schelling conjectures that, when individual interests are secondary to the primary need for coordination – that is, when the reward from coordinating is sufficiently large relative to the loss in payoff from not coordinating on one's preferred equilibrium – rational players can 'discipline' themselves to accept a lesser share if a useful cue points that way (p. 286).

It has been found that, consistently with Schelling's conjecture, certain kinds of labelling asymmetries are used as *cues* for achieving coordination in tacit bargaining games. Such asymmetries include the gender of the players (Holm, 2000) and which player is described as the first mover in a Battle of the Sexes game that is strategically equivalent to a simultaneous move game (Cooper et al., 1993; Güth et al., 1998). However, when coordination games are framed as *matching* games – that is, framed so that coordination requires both players to choose the *same* strategy – there is substantially less coordination on salient equilibria if there is conflict of interest than if there is not (Crawford et al., 2008; Faillo et al., 2017). In the most extreme cases, such as the 2×2 games in Crawford et al.'s experiment, coordination payoff differences of as little as two percent induce rates of coordination lower than would have resulted from random behaviour. In interpreting these findings, Crawford et al. propose a version of level-k theory (Stahl and Wilson, 1994; Nagel, 1995) in which payoff-irrelevant cues serve only as tie-breakers, with the implication that such cues are used only in the very special case of Pure Coordination games.[3]

This implication is clearly too extreme, even for matching games. In 3×3 matching games with conflicts of interest, Faillo et al. find evidence indicative of level-k reasoning but incompatible with focal-point reasoning, and evidence indicative of the opposite. The relevant games can be described by the three pairs of payoffs on the main diagonal of the payoff matrix, all other payoffs being zero and no label being salient. For example, in the 'G6' game $\{(10, 9), (9, 10), (9, 8)\}$ the third strategy is unique by virtue of its payoffs, but only 5.6 percent chose that strategy, consistently with level-k reasoning but contrary to focal-point reasoning. In the 'G7' game $\{(10, 9), (9, 10), (9, 9)\}$, 69 percent chose the third strategy, consistently with focal-point reasoning, when the level-k model implies that no player (except at 'level 0') should make that choice.

Isoni et al. (2013) investigate coordination games that are framed to incorporate aspects of real-world bargaining – particularly, that players make claims on specific valuable objects (with the implication that coordination requires players to choose *different* objects), that salient labelling cues take the form of relations between players and objects, and that some of the available surplus can be left unclaimed. In these games, there is significantly more coordination if such cues are present than if they are not. Nevertheless, for given cues, the presence of conflict of interest reduces coordination. This evidence suggests that, contrary to Schelling's hypothesis, given players are less likely to use focal-point reasoning, or use it less effectively, when they have conflicting rankings of coordination equilibria. Since such conflict is likely to occur in most real-world situations of coordination and bargaining, it is important to establish under what conditions focal-point reasoning is likely to be adopted.

The research reported in the present paper was prompted by the thought that most experiments fail to capture a key aspect of real-world situations of coordination and bargaining. Contrary to what happens in the lab, real-world players may not know exactly how much it is worth to them and their co-players to coordinate on a certain label or to reach a certain agreement. They may have better knowledge of their own utilities than their co-players', or sometimes even be unsure about their own utilities. By making payoff differences unambiguous and by establishing common knowledge about them, experimental games may overemphasise a kind of information that may be impossible for real-world agents to acquire with a comparable degree of precision. If the presence of conflict inhibits focal-point reasoning, the emphasis that lab experiments put on it may lead to wrong conclusions about its relevance for real-world settings. In order to conduct a more realistic test of how conflicts of interest affect focal-point reasoning, it is important to consider situations in which payoffs are less than perfectly known. This is the main objective of our paper.

To address our research question, we need to be able to manipulate payoff information in a setup in which there are focal points that reliably affect behaviour, and in which the inhibiting effect of conflicts of interests on focal-point reasoning has been observed and can be easily replicated. To this end, we adapt the *bargaining table* design used by Isoni et al. (2013). Our adaptation allows us to represent three simple types of 2×2 game with and without payoff-irrelevant labelling cues,

[1] Schelling (1960: 267–272) argues that if 'explicit' bargaining takes place over a finite period of time and if the procedure by which players communicate is 'perfectly move-symmetrical', there must be a final period in which a tacit bargaining subgame is played. If the solution to this subgame is common knowledge, no player will accept a lower payoff in earlier rounds of the game.

[2] The distinction between Pure Coordination and Battle of the Sexes games is often described as that between games with *symmetric* and *asymmetric payoffs* (e.g. Crawford et al., 2008). Because both types of game are invariant with respect to renaming players and strategies, we prefer to distinguish between the absence and presence of *conflict of interest*.

[3] Although Crawford et al.'s level-k model can account both for coordination success in Pure Coordination games and coordination failure in Battle of the Sexes, direct investigation of reasoning in those games by van Elten and Penczynski (2018) reveals marked differences between the two cases, with level-k reasoning more common in Battle of the Sexes games and Schelling-style 'team reasoning' in Pure Coordination games.

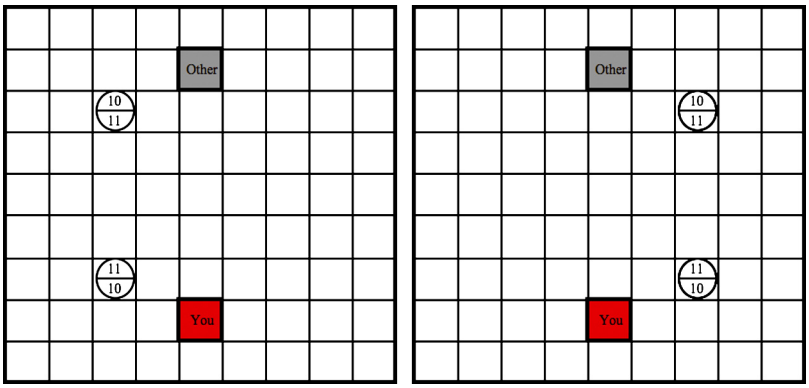


Fig. 1. A *Closeness* game viewed by two matched players. (For interpretation of the colours in the figure(s), the reader is referred to the web version of this article.)

all with two pure-strategy Nash equilibria: Pure Coordination games, Hi-Lo games (i.e., coordination games in which one pure-strategy equilibrium strictly Pareto dominates the other), and Battle of the Sexes games. Conflict of interest is present in the latter game, but not in the former two. Crucially, in the modified setup it is possible to vary the information that players have about the payoffs of the game, and hence whether conflicts of interest are common knowledge.

We study games that belong to one of three information conditions: a *Full Information* condition, in which both players know all payoffs; an *Own Information* condition, in which each player exactly knows her payoffs, but not the other player's; and a *No Information* condition, in which neither player knows the exact values of the payoffs. In all cases, the information condition is common knowledge. In the Full Information condition, it is common knowledge which of the three types of game is being played. In the other two conditions, neither player knows whether they are playing a Battle of the Sexes or a Hi-Lo game, hence whether there is conflict or not.[4]

Our initial conjecture was that focal-point reasoning would be more likely to be used, and hence labelling cues would be more effective, when conflicts of interest were less obvious. To formalise this conjecture, we develop a model in which each player is capable of using *both* focal-point *and* level-k reasoning (but not both at the same time); which of the two modes is more likely to be used in any given game is influenced by the presence or absence of conflicts of interest. The model organises the evidence, existing prior to our experiment and on which our conjecture was based, about the effect of labelling cues in the Full Information versions of Pure Coordination, Hi-Lo and Battle of the Sexes games. It makes new predictions for the Own and No Information games. In the Own Information condition, it predicts better coordination success than in Battle of the Sexes but worse than in Pure Coordination games. In the No Information condition, it predicts the same level of coordination success as in Pure Coordination games.

Surprisingly, our data provide no support for the hypothesis that de-emphasising conflicts of interest facilitates focal-point reasoning in one-shot tacit bargaining games. In the Own Information condition, players seem to find it hard to disregard unhelpful private information, and achieve levels of coordination that are, if anything, *lower* than in Battle of the Sexes games. Even in the No Information condition, coordination success falls short of the levels achieved in Pure Coordination games played under Full Information. Our results provide further evidence that the tension between focal-point and individual best-response reasoning such as level-k thinking is not easily resolved in the presence of conflicts of interest.

The remainder of this paper is organised as follows. Section 1 describes our adaptation of the bargaining table design. Our model is developed in Section 2. In Section 3, that model is used to derive hypotheses for our experiment. Section 4 gives details of how the experiment was implemented. We present our results in Sections 5, 6 and 7. Section 8 discusses the implications of these results and concludes.

1. Experimental design

The left-hand side of Fig. 1 shows one of the 'scenarios' faced by participants in our experiment. The scenario on the right-hand side is the same game as viewed by the matched player.

Taken together, the two scenarios constitute a tacit bargaining game represented by a 9×9 grid. The two squares represent the two players' respective *bases*. Each player knows which base is theirs because it is shown in red at the bottom

[4] Our focus on one-shot *tacit* coordination problems sets our contribution apart from the early work by Roth and Malouf (1979), Roth et al. (1981), and Roth and Murnighan (1982), who explored the effect of varying players' degree of payoff information in two-player *explicit* bargaining games with offers and counteroffers which resulted in lotteries for the two players, and found a broad tendency for agreements to be biased towards outcomes that equated the two players' expected experimental earnings. Our games also differ significantly from the matching games studied by Agranov and Schotter (2012), in which players learn to coordinate on the label-salient equilibrium in games with 'coarse' payoff information when these are played repeatedly with stranger matching and round-by-round feedback on the actual payoff configuration and realised outcomes. In line with Schelling's hypothesis, we study systematic coordination that occurs prior to any learning.

of the table they see and is labelled 'You'. For each player, it is straightforward to work out how the game looks from the 'Other' player's perspective.

There are two *discs* on the table, each split into two halves. There is a value in each half. The value on the half facing each base represents the value of the disc (in UK pounds) to the player assigned to that base. For the game in the example, each of the two discs is closer to one of the two bases. For each player, the *close* disc is worth £10 to them and £11 to the other player, while the *far* disc is worth £11 to them and £10 to the other player.

The game was described to participants as an 'opportunity to agree on a division of the discs'. Each player separately recorded which disc(s) she 'proposed to take' or 'claimed'. If no disc was claimed by both players, the players were said to have 'agreed'; each player earned the total value to her of the discs she had claimed. If *any* disc was claimed by both players, there was 'no agreement', and neither player earned anything from the game.[5]

For the game in Fig. 1, each player's strategies can be described as either: claim *none* of the discs, claim the *close* disc only, claim the *far* disc only, or claim *both* discs. Claiming none of the discs is a weakly dominated strategy. If this strategy is eliminated, claiming both discs is weakly dominated. After iterated elimination of weakly dominated strategies, we are left with a 2×2 game with the payoffs shown below[6]:

		Other	
		Close	*Far*
You	*Close*	10, 10	0, 0
	Far	0, 0	11, 11

The distinction between '*Close*' and '*Far*' represents a distinction between the two equilibria that is common knowledge between the players and that has the potential to be used as a means of coordination. The matrix describes a Hi-Lo game with two Pareto-ranked Nash equilibria in pure strategies ([*Close*, *Close*] and [*Far*, *Far*]) and a mixed-strategy Nash equilibrium (each player plays *Close* with probability 11/21). Given that players are described as 'You' and 'Other', the only information that would allow a player to distinguish between the two pure strategies is the difference between getting 10 or 11 and the relative salience of *Close* and *Far*.

If our design is to identify the positive and negative effects of labelling cues on coordination, we need a control condition in which such cues are either absent or ineffective. It might seem that the obvious way to implement control would be to remove the two player's bases and show exactly the same display to both players. While this may work in a game like the one in the example, it would be unsatisfactory for Battle of the Sexes and Pure Coordination games, which (apart from labelling) are perfectly symmetrical with respect to players and strategies. In such an alternative control version of these games, the only strategy descriptions available to the players would share the property that coordination would require them to choose *different* strategies. But without communication, players who identify themselves only as 'me' and 'other' would have no means of achieving such coordination. Thus, this control would fundamentally change the nature of the game.[7]

For our purposes, the most useful control condition is one in which labelling cues remain, but are minimally salient. Following the precedent of previous bargaining table experiments (Isoni et al., 2013, 2014), we match games with closeness cues with 'spatially neutral' games. An example of how such a game would look for two matched players is shown in Fig. 2.

This is essentially the same as the previous game, except for the positions of the two discs, which are now equidistant from the two bases. From the point of view of each player, the strategies can be described as either: claim *none* of the discs, claim the disc more to the *left* as seen from your base, claim the disc more to the *right* as seen from your base, or claim both discs. After iterated elimination of weakly dominated strategies, this game can be presented in normal form as:

		Other	
		Left	*Right*
You	*Left*	10, 10	0, 0
	Right	0, 0	11, 11

This payoff matrix is identical to that for the game in Fig. 1, except for the labels. Like that game, this has two pure-strategy equilibria ([*Left*, *Left*] and [*Right*, *Right*]) and a mixed-strategy Nash equilibrium (each player plays *Left* with probability 11/21).

[5] Although all our games have just two discs, we allowed players to also claim none or both discs. Isoni et al. (2013) looked at the effect of forcing players to claim exactly one disc and found that, other things being equal, that somewhat reduced the salience of closeness cues. Because we need salient cues to address our research question, we used the version of the games in which none or both discs could be claimed. This has also the advantage of preserving the bargaining feel of the game.

[6] As a necessary step for experimental implementation, we use the term 'payoff' to refer to *material* payoffs (expressed in money units), but treat these as if, for each player considered separately, they were close proxies for utilities in the sense of classical game theory. As in that theory, we make no assumptions about the interpersonal comparability of utility.

[7] Compare the concept of *attainability* in Crawford and Haller (1990) and Blume (2000).

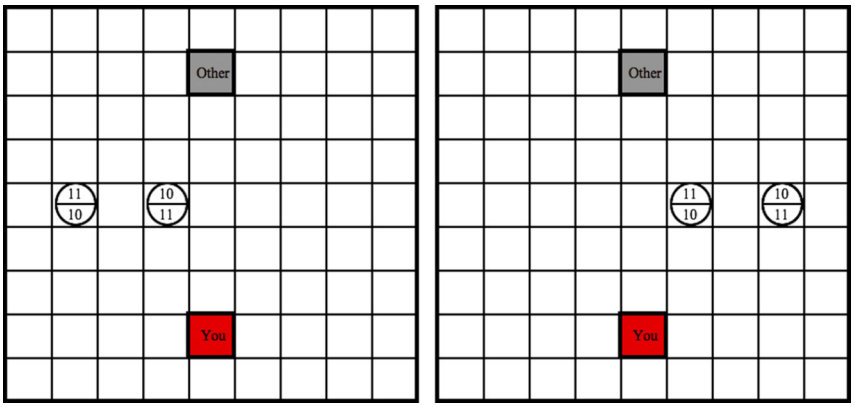


Fig. 2. A *Spatially Neutral* game viewed by two matched players.

In both games considered so far, there are labelling cues that in principle could be used as a means of coordination but, intuitively, it seems clear that the rule of choosing the disc that is more to the left (or to the right) is likely to be much less conducive to coordination than the rule of choosing the disc closer to one's base. And in fact, there is strong evidence that this is the case (e.g., Mehta et al., 1994b; Isoni, et al., 2013, 2014). Our experimental design is premised on the assumption that, when both discs are equidistant from the two bases, players who try to use spatial location as a coordination device will distribute their choices between the discs with approximately equal probability. Given this assumption, such games can be used as controls. Our design allows us to check the validity of this assumption.

In order to assess the ability of payoff-irrelevant cues to influence coordination success, we will contrast *Closeness* games in which (as in Fig. 1) there is one disc closer to each base, and *Spatially Neutral* games in which (as in Fig. 2) both discs are equidistant from the two bases. Our experiment was designed to study the effects of closeness cues in a variety of situations, including different degrees of conflict between coordination equilibria and information about the value of each disc to each player.

In the remainder of this paper, we will use the word *scenario* to indicate a game as seen by an individual player, and the word *game* to indicate the result of two matching scenarios like those in Figs. 1 and 2. In each scenario, the positions of the two discs were always common knowledge, and there was a *disc value pair* $\{X, Y\}$ with $0 < X \leq Y$, which was also common knowledge. For each player, there was always one disc worth X and one disc worth Y. The particular configuration of which disc was worth X and which was worth Y for each player will be called the *assignment* of disc values. When $X = Y$, there is just one possible assignment of values to discs, which is necessarily common knowledge. This produces a Pure Coordination game. When $X < Y$, there are four possible assignments of disc values. Two of these produce Hi-Lo games, in which the players' interests are fully aligned; the other two produce Battle of the Sexes games, in which the players have conflicting rankings of the two equilibria. In different information conditions, players had different degrees of information about this assignment. When players were not fully informed about the actual assignment, each of the four possible assignments had the same prior probability.

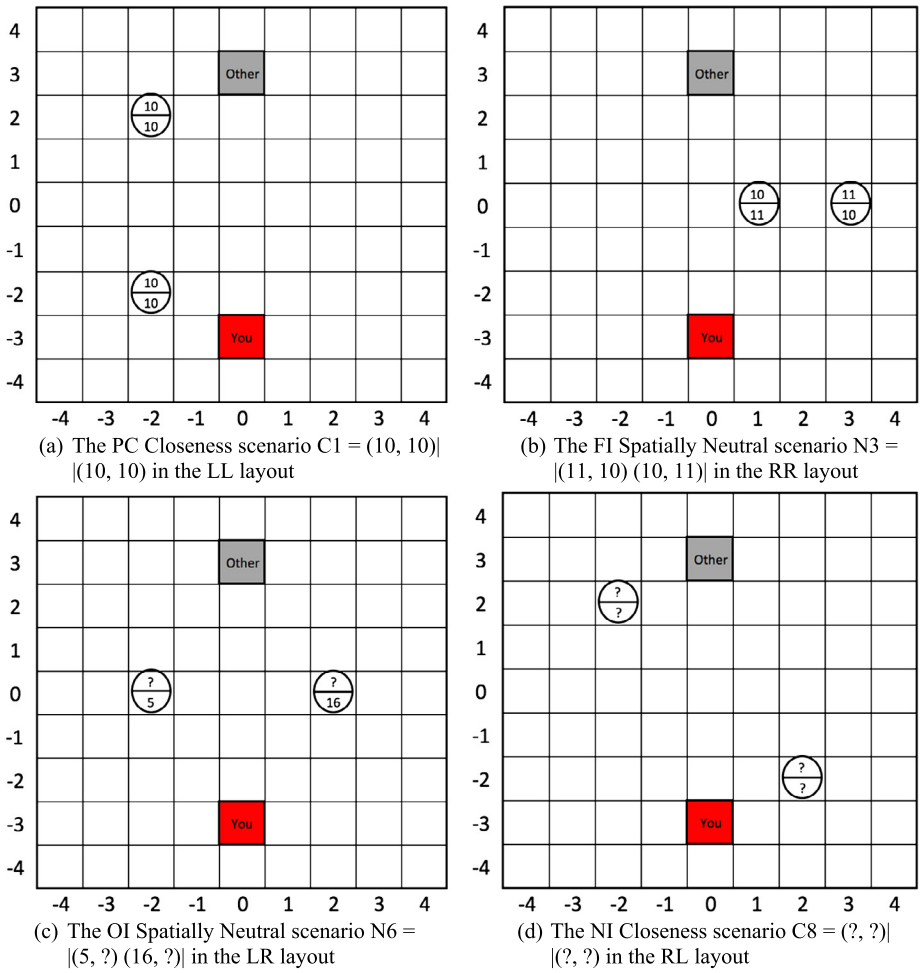
The scenarios used in the experiment can be grouped into four classes, defined in terms of disc values and information conditions.

In *Pure Coordination* (PC) scenarios, it is common knowledge that $X = Y$, and hence that the players are facing a Pure Coordination game. These scenarios allow us to verify that, in the absence of conflict of interest, closeness cues are more salient than other cues. An example of a Pure Coordination scenario is shown in Fig. 3a.[8]

In the other three classes of scenarios, it is common knowledge that $X < Y$. In *Full Information* (FI) scenarios, the assignment of disc values is common knowledge. Thus, it is common knowledge that the players are facing a Hi-Lo game or a Battle of the Sexes game. If the game is Hi-Lo, it is common knowledge if closeness is *congruent* or *incongruent* with payoffs – i.e., whether or not the payoff dominant equilibrium has a salient label. If the game is Battle of the Sexes and if there is one disc on each player's side of the table, the 'You' player can either be *favoured* by closeness (scenario C5) or *unfavoured* (scenario C4). An example of an FI scenario is shown in Fig. 3b; this is part of a Hi-Lo game.

In *Own Information* (OI) scenarios, each player knows the value of each disc to her but not their values to the other player; this is common knowledge. In our displays, the 'Other' player's disc values are replaced by question marks. From these displays and from the information at her disposal, each player can figure out that her scenario may be part of either a Hi-Lo game or a Battle of the Sexes game. In scenario C6, closeness is *bad* for the 'You' player (the close disc is worth X), in scenario C7 it is *good* (the close disc is worth Y). An example of an OI scenario is shown in Fig. 3c.

[8] The numbers that appear next to the left and bottom edge of the bargaining tables in Fig. 3 are coordinates that uniquely identify the positions of the two discs. These were not shown to participants, but will be used in Section 4 to describe the exact 'layouts' of discs. In the experiment, the disc values were preceded by the '£' symbol.



(a) The PC Closeness scenario C1 = (10, 10)| |(10, 10) in the LL layout

(b) The FI Spatially Neutral scenario N3 = |(11, 10) (10, 11)| in the RR layout

(c) The OI Spatially Neutral scenario N6 = |(5, ?) (16, ?)| in the LR layout

(d) The NI Closeness scenario C8 = (?, ?)| |(?, ?) in the RL layout

Fig. 3. Examples of experimental scenarios.

From the viewpoint of classical game theory, these scenarios represent games of incomplete information. After iterated elimination of weakly dominated strategies, each of these games has three pure-strategy Bayesian Nash equilibria: one in which both players always choose the close (respectively, left) disc, one in which both players always choose the far (right) disc, and one in which each player always chooses the disc that is worth Y to her. The first two of these equilibria result in perfect coordination, while the last results in successful coordination only fifty percent of the time. There are also two mixed-strategy equilibria, in one of which the close (respectively, left) disc, and in the other the far (respectively, right) disc is claimed with probability 1 when it is worth Y and with probability $(Y - X)/(X + Y)$ when it is worth X.[9]

In *No Information* (NI) scenarios, the assignment is completely unknown to both players; this is common knowledge. In our displays, all disc values are replaced by question marks. From these displays and from the information at their disposal, each player can figure out that her scenario may be part of either one of two Hi-Lo games or be one of the two scenarios making up a Battle of the Sexes game. An example of an NI scenario is shown in Fig. 3d.

The scenarios used in the experiment can also be classified according to the spatial locations of the discs. In *Closeness* scenarios, such as those shown in Figs. 3a and 3d, one disc is closer to the 'You' base and the other is closer to the 'Other' base. In *Spatially Neutral* scenarios, such as those shown in Figs. 3b and 3c, both discs are equidistant from the two bases; necessarily, one disc is more to the left, as viewed from the 'You' base.

To maintain symmetry in our design, every Closeness scenario has a corresponding Spatially Neutral scenario, and vice versa. In each pair of corresponding scenarios, the two scenarios belong to the same class (PC, FI, OI or NI) and have the same disc value pair. Recall that in a Closeness scenario of class FI or OI, the 'You' player knows whether the disc that is closer to her base is more or less valuable to her than the disc that is further away. In a corresponding Spatially Neutral scenario, the 'You' player knows whether the disc that is more to her left is more or less valuable to her than the disc that is more to her right. We adopt the convention that a Closeness scenario in which the more valuable disc is closer to

[9] These equilibria are derived in the Appendix.

Table 1
Types of scenario used in the experiment.

Class (game)	Spatially neutral scenarios		Closeness scenarios		
	Configuration	Match	Configuration	Match	Closeness cue
PC	N1 = |(X, X) (X, X)|	N1	C1 = (X, X)| |(X, X)	C1	Sole cue
FI (HL–I)	N2 = |(X, Y) (Y, X)|	N2	C2 = (X, Y)| |(Y, X)	C2	Incongruent with payoffs
FI (HL–C)	N3 = |(Y, X) (X, Y)|	N3	C3 = (Y, X)| |(X, Y)	C3	Congruent with payoffs
FI (BS)	N4 = |(X, X) (Y, Y)|	N5	C4 = (X, X)| |(Y, Y)	C5	Favours 'Other'
FI (BS)	N5 = |(Y, Y) (X, X)|	N4	C5 = (Y, Y)| |(X, X)	C4	Favours 'You'
OI	N6 = |(X, ?) (Y, ?)|	N6, N7	C6 = (X, ?)| |(Y, ?)	C6, C7	Bad for 'You'
OI	N7 = |(Y, ?) (X, ?)|	N6, N7	C7 = (Y, ?)| |(X, ?)	C6, C7	Good for 'You'
NI	N8 = |(?, ?) (?, ?)|	N8	C8 = (?, ?)| |(?, ?)	C8	Sole cue

Notes: PC = Pure Coordination; FI = Full Information; OI = Own Information; NI = No Information; HL–I = Hi-Lo with Incongruent cues; HL–C = Hi-Lo with Congruent cues; BS = Battle of the Sexes.

the 'You' base corresponds with a Spatially Neutral scenario in which the more valuable disc is more to the left. Given our premise that neither left nor right is salient, this convention is inconsequential to our analysis.[10]

Table 1 presents an overview of the types of scenarios that participants faced in our experiment. In describing scenarios, we use the following notation. Discs are shown by two entries in parentheses, in which the first entry is the value of the disc to the participant ('You'), and the second is the value to the player they are facing ('Other'). For example, (X, Y) denotes a disc worth X to 'You' and Y to 'Other'; $(Y, ?)$ is a disc worth Y to 'You' and either X or Y to 'Other'; (?, ?) is a disc worth either X or Y both to 'You' and 'Other'. The two vertical bars | | are used to identify the middle row of the table as seen by the participant. In Closeness games, the close disc is shown to the left of | | and the far disc to the right. In Spatially Neutral games, both discs are between the two bars, the first disc indicating the leftmost disc as seen by the participant, the second indicating the rightmost disc. For example, the scenario on the left-hand side of Fig. 1 is C2 = $(X, Y)| \,|(Y, X)$, with $X = 10$ and $Y = 11$. The scenario on the right-hand side of Fig. 2 is N2 = $|(X, Y)(Y, X)|$, also with $X = 10$ and $Y = 11$.

Table 1 presents the eight Spatially Neutral scenarios used in the experiment (N1 to N8) and the corresponding Closeness scenarios (C1 to C8). Each row describes a pair of corresponding scenarios. The first column shows whether these scenarios are of class PC, FI, OI or NI (and the corresponding game for the FI scenarios). The 'Match' columns identify the scenario faced by 'Other' when the relevant scenario is faced by 'You'. This matching is a matter of logical necessity, because in any given scenario a player can work out what scenario (or, in the case of the Own Information condition, what scenarios) 'Other' is (might be) facing. In most cases, the matched player faces the same scenario, but there are some exceptions. For example, scenario C5 is part of a Battle of the Sexes game in which the best equilibrium for 'You' is the one in which each player claims the disc closer to her base. The matched player necessarily faces scenario C4, in which the best equilibrium for 'You' is the one in which each player claims the disc further from her base. The last column describes how the closeness cue relates to payoffs.

2. A simple model of multiple modes of reasoning

In order to derive hypotheses for the games in our experiment, we develop a model which organizes the main findings of previous experiments on Pure Coordination, Battle of the Sexes and Hi-Lo games. We begin by modelling players' choices of pure strategies in (full information) 2×2 *diagonal coordination games* in which player labels are symmetric (e.g. 'You' and 'Other', as in Fig. 1 and Fig. 2). In a 2×2 diagonal coordination game, each player $i = 1, 2$ has strategies $j = 1, 2$, where each strategy j has a distinct payoff-irrelevant label l_j known to both players. If both players choose the same strategy j, the payoffs to players 1 and 2 are π_{1j} and π_{2j}, with $\pi_{1j}, \pi_{2j} > 0$; otherwise (i.e., off the main diagonal of the payoff matrix), both players' payoffs are zero. Payoffs are common knowledge. Any such game has two pure-strategy Nash equilibria, in each of which the players' strategies have the same label, and a mixed-strategy equilibrium in which both players' expected payoffs are lower than in either pure-strategy equilibrium.

We model each player as being capable of using two alternative *modes of reasoning*: *focal-point reasoning*, as theorised by Schelling (1960) and developed by Bacharach (2006), and *level-k reasoning*, as modelled by Crawford et al. (2008). In each game, the modes of reasoning used by the players are determined by two independent realisations (one for each player) of a random mechanism, using probabilities that are the same for both players but might vary according to the specification of the game. This modelling strategy is justified by our objective to match the evidence, summarised earlier, that *even in the same experiment* behaviour in some games is more in line with one form or reasoning, while behaviour in other games is more compatible with the other (e.g. Faillo et al., 2017). A model that treated each mode of reasoning as an unconditional property of a distinct player 'type' would not be able to explain this evidence.

[10] This premise is confirmed (see Section 5).

We assume that each mode of reasoning is *self-contained* – that is, a player who uses it acts as if believing that the other player uses it too. This assumption appears the most psychologically plausible, given the bounded rationality of ordinary human players: reasoning about the game in multiple ways is much more cognitively demanding than using a single mode of reasoning.[11] In addition, the evidence that salient labelling cues can be ineffective in Battle of the Sexes games would be difficult to explain if players who used one mode of reasoning were allowed to believe that their co-players might be using the other. The difficulty here is that, under reasonable assumptions, players who mix modes of reasoning in this way can be predicted to choose the saliently-labelled strategy in a Battle of the Sexes game.

The most natural way to represent the idea that level-k reasoners believe that their co-players might be using focal-point reasoning is to assume that a significant proportion of level-0 players (i.e., those who are using focal-point reasoning) choose the strategy with the more salient label. But in Battle of the Sexes games with small payoff differences, all higher-level players would then choose the saliently labelled strategy and so coordinate successfully. The mirror-image idea, that focal-point reasoners believe that their co-players might be using level-k reasoning, can be modelled using the concept of *circumspect team reasoning* (Bacharach, 1999). Roughly, the idea is that sophisticated players look for a strategy combination that is optimal for the players taken together, treating the behaviour of naïve players (in this case, level-k reasoners) as a constraint. But (as we will show) the overall effect of level-k reasoning in Battle of the Sexes games is to produce *dis*coordination. Taking this behaviour as given, circumspect team reasoners would choose the saliently labelled strategy so as to coordinate with one another.

Players who use focal-point reasoning try to discriminate between pure-strategy Nash equilibria by using only information that is common knowledge. When describing focal-point reasoning, Schelling (1960, pp. 83, 96, 106, 163, 298) often uses the metaphor of a 'meeting of minds' between the players. The suggestion is that, in choosing their strategies, the players imagine themselves reasoning *together* about how to coordinate their behaviour.[12] A natural implication of this idea is that, in their reasoning, players use only information that is common knowledge between them. Items of such knowledge that can be used in this way will be called *cues*. Players will concentrate on cues that are *salient* – i.e., that can easily be recognised by both players – and *discriminating* – i.e., that can identify one of the Nash equilibria as the solution of the game. Given that player labels are symmetric, there are only two plausible types of cue that can pick out a specific pure-strategy equilibrium. There is a cue of *label salience* if one equilibrium stands out relative to the other by having a more salient label attached to the corresponding strategy. There is a cue of *joint-payoff salience* if one equilibrium stands out by having a pair of payoffs that is better for the players collectively, according to some salient criterion of 'betterness' that treats the players symmetrically. For our purposes, we can restrict the criterion to payoff dominance.

Our model of level-k reasoning is taken from Crawford et al. (2008). Each player reasons at one the *levels* 0, 1, 2, ... Each player's reasoning level is an independent draw from an exogenously given distribution, in which level 0 has zero probability. A player at any level $L \geq 1$ believes that her co-player is at level $L-1$, and uses iterated best-response reasoning to form a belief about what that co-player will choose. This reasoning is anchored on beliefs about the behaviour of level-0 players.[13] A level-0 player is believed to have a probability distribution over strategies which shows a *payoff bias* (i.e., it assigns higher probability to strategies whose equilibria have higher own payoff). Payoff bias is independent of the size of the payoff difference. Labels are irrelevant for level-0 behaviour except when all equilibria have the same own payoff, in which case strategies with more salient labels are chosen with higher probability.

Following Bacharach's (2006) theory of *team reasoning*, we assume that the probability that a player uses focal-point reasoning depends on the likelihood that they *identify* with the *group* made of themselves and their co-player. In Bacharach's theory, group identification is facilitated by a variety of factors, including being members of the same pre-existing social group or ad-hoc category (Tajfel, 1970), being exposed to the pronouns 'we', 'our' or similar (Perdue et al., 1990), having common interest or common fate (Rabbie and Horwitz, 1969), sharing experiences (Prentice and Miller, 1992), making face-to-face contact (Dawes et al., 1988), or being interdependent (Sherif et al., 1961). For our purposes, we assume that the probability that players use focal-point reasoning depends only on the players' common knowledge about the presence or absence (and if present, the degree) of *conflict of interest*. There is conflict of interest if the players have opposing preferences between the two pure-strategy Nash equilibria.

We now apply this model to the games in our experiment, after iterated elimination of dominated strategies. Initially, we consider Pure Coordination games and Full Information games (i.e., Hi-Lo and Battle of the Sexes). These are 2×2 diagonal coordination games with $l_j = Close, Far$ in the Closeness version or $l_j = Left, Right$ in the Spatially Neutral version, and $\pi_{ij} \in \{X, Y\}$ (with $0 < X \leq Y$). We assume that the [*Close*, *Close*] equilibrium is label-salient in all Closeness games, that neither equilibrium is label-salient in Spatially Neutral games, and that the $[Y, Y]$ equilibrium has joint-payoff salience

[11] Costa-Gomes and Weizsäcker (2008) found that subjects play games as if attributing less rationality to their opponents than to themselves, but when stating their beliefs about their opponents' strategy choices, 'they put themselves in the shoes of their opponent' (p. 757), and reason about their opponents' decisions as if they were theirs.

[12] This aspect of Schelling's theory of focal points is examined by Sugden and Zamarrón (2006). The concept of players reasoning together has been developed theoretically in the theories of *team reasoning* (e.g. Sugden, 1993; Bacharach, 2006) and *virtual bargaining* (Misyak and Chater, 2014).

[13] An alternative best-response model based on limited levels of reasoning is Camerer et al.'s (2004) *cognitive hierarchy model*, in which players at higher levels best respond to some distribution of lower levels. Keeping the assumptions about the level-0 player unchanged, using a cognitive hierarchy specification would not alter the qualitative predictions summarised in our hypotheses: see footnote 17.

in Hi-Lo games. Notice that, by virtue of the symmetry properties of Pure Coordination and Battle of the Sexes, neither equilibrium in those games can have joint-payoff salience.

There is conflict of interest in Battle of the Sexes but not in Pure Coordination or Hi-Lo. In Battle of the Sexes, the degree of conflict of interest depends on the values of X and Y. The probability that a player uses focal-point reasoning is given by a function $\varphi(X, Y)$, with $0 < \varphi(X, Y) < 1$.[14] We assume that there is some probability φ_0 such that $\varphi(X, Y) = \varphi_0$ if there is no conflict of interest and $\varphi(X, Y) < \varphi_0$ otherwise. We also assume that φ is weakly increasing in X and weakly decreasing in Y (i.e., focal-point reasoning is weakly less likely, the greater the degree of conflict of interest). By not assuming φ to be continuous, we allow the possibility that even small conflicts of interest may significantly inhibit focal-point reasoning, as existing evidence suggests (Crawford et al., 2008; Isoni et al., 2013; Faillo et al., 2017).

In the Closeness versions of Pure Coordination and Battle of the Sexes, a player who uses focal-point reasoning is assumed to choose *Close* with probability 1. In the Closeness versions of Hi-Lo games, there are cues of both label salience and joint-payoff salience. We assume that, conditional on having adopted focal-point reasoning in such a Hi-Lo game, each player has an independent probability $\sigma(X, Y)$ of being guided by joint-payoff salience (and therefore choosing the strategy leading to the payoff-dominant equilibrium); otherwise, she is guided by label salience (and therefore chooses the label-salient strategy). We assume that $0 < \sigma(X, Y) < 1$ for all X, Y, and that $\sigma(X, Y)$ is weakly increasing in Y and weakly decreasing in X. (Intuitively, the greater the value of Y relative to X, the more salient is the cue that points to the payoff-dominant equilibrium.) In the Spatially Neutral versions of Hi-Lo games, a player who uses focal-point reasoning has only the joint-payoff salience cue available, and therefore chooses the strategy leading to the payoff-dominant equilibrium with probability 1. In the remaining Spatially Neutral games, which do not have joint-payoff salient cues, a player who uses focal-point reasoning chooses each strategy with probability 0.5.

Now consider the behaviour of a player who uses level-k reasoning. Because level-0 players tend to use label salience as a tie-breaker, and because this level occurs with zero probability, level-k reasoning implies that *Close* is chosen with probability 1 in the Closeness version of Pure Coordination, irrespective of the distribution of reasoning levels. In the Spatially Neutral version of Pure Coordination, level-k reasoning does not discriminate between the two strategies, and so each is chosen with probability 0.5. Because label salience is used *only* as a tie-breaker, the distinction between the Closeness and Spatially Neutral versions of Hi-Lo and Battle of the Sexes is irrelevant for level-k reasoning. In Hi-Lo, level-k reasoning implies that the Y strategy (i.e., the strategy leading to the Nash equilibrium in which the player's payoff is Y) is chosen with probability 1. In Battle of the Sexes, the implications of level-k reasoning depend on the distribution of reasoning levels. For our purposes, however, it is sufficient to treat this distribution as exogenous, and to define $\rho(X, Y)$ as the probability with which, given this distribution, a randomly-selected level-k reasoner chooses her Y strategy.[15]

We now extend our model to Own Information and No Information games. First, we consider Own Information games. Recall that, after iterated elimination of weakly dominant strategies, these games have three pure-strategy Bayesian Nash equilibria – two equilibria in which each player's expected payoff is $(X + Y)/2$ and one in which it is $Y/2$. Thus, no equilibrium stands out as having uniquely best joint payoffs. We therefore treat these games as having no cues of joint-payoff salience. The Closeness version of the game has a cue of label salience; the Spatially Neutral version does not. We therefore assume that, for focal-point reasoners, *Close* is chosen with probability 1 in the Closeness version of the game and *Left* is chosen with probability 0.5 in the Spatially Neutral version.[16] Level-k reasoning has very different implications. For a level-0 player, payoff bias will favour the choice of the disc that gives her Y. But, since a level-1 player does not know which disc this is, his best response is to choose the disc that gives *him* Y; and similarly for higher levels of reasoning. Thus, in both versions of the game, level-k reasoners choose the Y strategy with probability 1.

Finally, we consider the No Information games. After iterated elimination of dominated strategies, these games are equivalent to Pure Coordination games in which the expected payoff from coordination is $(X + Y)/2$ to both players in both pure-strategy equilibria. Thus, as in Pure Coordination games, all players choose *Close* with probability 1 in the Closeness version of the game and *Left* with probability 0.5 in the Spatially Neutral version.

Table 2 summarises the key properties of our model, and its predictions for the six types of games used in our experiment. Each horizontal panel refers to the Closeness and Spatially Neutral versions of a given game type. For each version, we first report the probability distribution over possible types of players resulting from the random draw which determines their mode of reasoning (recall that, *ex ante*, each player has a positive probability of adopting either mode of reasoning): focal-point reasoners who use the cue of label salience (type F), focal-point reasoners who use the cue of joint-payoff salience (type FP, only for Hi-Lo games), and level-k reasoners (type K). For each type, we show the probability that a player claims the close disc (in Closeness games) or the left disc (in Spatially Neutral games); where applicable, we report the

[14] Given our objective to produce a model that matches the evidence available before our experiment, and given that, as noted earlier, neither focal-point reasoning nor level-k reasoning can in isolation explain all the findings, we need that both types of reasoning occur with positive probability.

[15] It is possible for $\rho(X, Y)$ to be less than 0.5. If the degree of conflict of interest is sufficiently small, level-1 players respond to the payoff bias of level-0 players by choosing the X strategy; level-2 players respond by choosing the Y strategy, and so on. Thus, whether $\rho(X, Y)$ is greater or less than 0.5 depends on the distribution of reasoning levels.

[16] In the Own Information games, the three pure-strategy equilibria give each player a payoff of $(X+Y)/2$, $(X+Y)/2$ and $Y/2$ respectively. Sophisticated players might reason that choosing on the basis of equilibrium payoffs alone would make the expected payoff from choosing at random between the two identical equilibria $(X+Y)/4$, and therefore the equilibrium with a payoff of $Y/2$ would be superior. Our model assumes a more naïve approach to unique joint-payoff salience, in line with empirical evidence (e.g. Faillo et al., 2017).

Table 2
Model Predictions.

Game		Closeness game				Spatially neutral game			
		Pr(Case)	Pr(Close)	Pr(Y)	Pr(Coord)	Pr(Case)	Pr(Left)	Pr(Y)	Pr(Coord)
Pure Coordination	F	φ_0	1	n/a	–	φ_0	0.5	n/a	–
	K	$(1 - \varphi_0)$	1	n/a	–	$(1-\varphi_0)$	0.5	n/a	–
	Label vs. Label	1	–	–	1	1	–	–	0.5
Hi-Lo Incongruent	F	$\alpha = \varphi_0[1-\sigma(X,Y)]$	1	0	–	0	n/a	n/a	–
	FP	$\beta = \varphi_0[\sigma(X,Y)]$	0	1	–	φ_0	0	1	–
	K	$\gamma = (1-\varphi_0)$	0	1	–	$(1-\varphi_0)$	0	1	–
	Label vs. Label	α^2	–	–	1	φ_0^2	–	–	1
	Payoff vs. Payoff	$(\beta+\gamma)^2$	–	–	1	$(1 - \varphi_0)^2$	–	–	1
	Label vs. Payoff	$2\alpha(\beta+\gamma)$	–	–	0	$2\varphi_0(1-\varphi_0)$	–	–	1
Hi-Lo Congruent	F	$\alpha = \varphi_0[1--\sigma(X,Y)]$	1	1	–	0	n/a	n/a	–
	FP	$\beta = \varphi_0[\sigma(X,Y)]$	1	1	–	φ_0	1	1	–
	K	$\gamma = (1-\varphi_0)$	1	1	–	$(1 - \varphi_0)$	1	1	–
	Label vs. Label	α^2	–	–	1	φ_0^2	–	–	1
	Payoff vs. Payoff	$(\beta+\gamma)^2$	–	–	1	$(1 - \varphi_0)^2$	–	–	1
	Label vs. Payoff	$2\alpha(\beta+\gamma)$	–	–	1	$2\varphi_0(1 - \varphi_0)$	–	–	1
Battle of the Sexes	F	$\varphi(X,Y)$	1	0.5	–	$\varphi(X,Y)$	0.5	0.5	–
	K	$[1-\varphi(X,Y)]$	0.5	$\rho(X,Y)$	–	$[1-\varphi(X,Y)]$	0.5	$\rho(X,Y)$	–
	Label vs. Label	$[\varphi(.)]^2$	–	–	1	$[\varphi(.)]^2$	–	–	0.5
	Level-k vs. Level-k	$[1-\varphi(.)]^2$	–	–	$\rho * (X,Y)$	$[1-\varphi(.)]^2$	–	–	$\rho * (X,Y)$
	Label vs. Level-k	$2[\varphi(.)][1-\varphi(.)]$	–	–	0.5	$2[\varphi(.)][1-\varphi(.)]$	–	–	0.5
Own Information	F	φ_0	1	0.5	–	φ_0	0.5	0.5	–
	K	$(1-\varphi_0)$	0.5	1	–	$(1-\varphi_0)$	0.5	1	–
	Label vs. Label	φ_0^2	–	–	1	φ_0^2	–	–	0.5
	Payoff vs. Payoff	$(1 - \varphi_0)^2$	–	–	0.5	$(1-\varphi_0)^2$	–	–	0.5
	Label vs. Payoff	$2\varphi_0(1-\varphi_0)$	–	–	0.5	$2\varphi_0(1-\varphi_0)$	–	–	0.5
No Information	F	φ_0	1	n/a	–	φ_0	0.5	n/a	–
	K	$(1-\varphi_0)$	1	n/a	–	$(1-\varphi_0)$	0.5	n/a	–
	Label vs. Label	1	–	–	1	1	–	–	0.5

Notes: F = focal-point reasoner using label salience; FP = focal-point reasoner using joint-payoff salience; K = level-k reasoner. φ_0 = probability of focal-point reasoning absent conflict of interest; $\varphi(X,Y)$ = probability of focal-point reasoning when there is conflict of interest and payoff pair is $\{X,Y\}$; $\sigma(X,Y)$ = probability that a focal-point reasoner uses joint-payoff salience in Hi-Lo games; $\rho(X,Y)$ = probability that a level-k reasoner claims the disc worth Y in Battle of the Sexes; $\rho^*(X,Y) = 2\rho(X,Y)[1-\rho(X,Y)]$; n/a = not applicable.

probability that a player claims the disc worth Y to her. So, for example, in Pure Coordination and No Information games the probabilities that a player uses focal-point reasoning or level-k reasoning are φ_0 and $(1-\varphi_0)$ respectively. Both types chose the label-salient strategy with probability 1, so Pr(Close) equals 1 for both types. In Hi-Lo games (with either congruent or incongruent cues), the probability that a focal-point reasoner chooses on the basis of label salience is $\varphi_0[1-\sigma(X,Y)]$, the probability that a focal-point reasoner uses joint-payoff salience is $\varphi_0[\sigma(X,Y)]$, and the probability of level-k reasoning is $(1-\varphi_0)$. In these games, all players choose the Y strategy with probability 1, except for the F types, who choose the X strategy with probability 1 in the Closeness version of Hi-Lo with incongruent cues. In Battle of the Sexes games, the distribution of types depends on the conflict of interest induced by the values of X and Y, according to the function $\varphi(X,Y)$.

We can use these choice probabilities to look at coordination success – i.e., the probability that two players, chosen at random, coordinate with each other. We do this by considering the specific behaviour of each type in each game. In Pure Coordination and No Information games, all players choose according to label salience, so the probability of coordination is necessarily 1. In all other games, irrespective of the number of different player types, there are just two different types of behaviours. In all cases, except Battle of the Sexes, players can either choose the label-salient strategy ('Label' in Table 2) or the strategy with a better own payoff ('Payoff'). (Notice that, although there are three types of players in Hi-Lo games, FP players behave like level-k players and choose the Y strategy.) In Battle of the Sexes, a player can either choose the label-salient strategy or play as a level-k reasoner (in which case their actual choice depends on their level). Two randomly-chosen players can either use the same behavioural rule or different ones. Two independent draws of two players who use one of two rules (i.e., Label and Payoff) may result in one of three possible combinations (i.e., Label vs. Label, Payoff vs. Payoff, Label vs. Payoff). The probability of each combination for each game is shown in each panel of Table 2, together with the corresponding probability of coordination Pr(Coord). Note that if one player chooses at random, the probability of successful coordination is necessarily 0.5, irrespective of the behaviour of her co-player. In a Battle of the Sexes game between two randomly-selected level-k reasoners, the probability that they coordinate (i.e., that one gets a payoff of Y and

the other gets X) is given by $\rho^*(X,Y) = 2\rho(X,Y)[1-\rho(X,Y)]$. Notice that $\rho^*(X,Y) \leq 0.5$: unless the X and Y strategies are chosen with exactly equal probability, level-k reasoning induces *dis*coordination.[17]

3. Hypotheses

We now use the information in Table 2 to derive our formal hypotheses about coordination success in our games. In interpreting our hypotheses, one should bear in mind that, in the interests of simplicity, our model assumes away the mistakes players could make when implementing their strategies (or, equivalently, the existence of players who choose at random). Thus, the specific values of coordination success generated by the model should not be treated as firm predictions about the behaviour of real players. However, the qualitative nature of our predictions should not be affected by moderate degrees of noise in behaviour, which are inevitably present in experimental data. For this reason, our hypotheses will focus on the direction of the difference between coordination success in different types of game.

We begin with comparisons within the panels of Table 2, and look at the effects of salient labels keeping the type of game constant. The Pure Coordination games (faced in scenarios C1 and N1) can be used to test the underlying assumption of our design that closeness is a much stronger cue than any cue contained in Spatially Neutral games. In the Spatially Neutral version we expect coordination success to approximate that implied by random behaviour, and to be much higher in the Closeness version. Since this directional effect is essentially a prerequisite for the rest of our analysis, we will call it Hypothesis 0:

Hypothesis 0 *(PC games). With full information and $X = Y$, coordination success is higher in Closeness games than in Spatially Neutral games.*

Our predictions concerning the effect of closeness in Full Information games are summarised in Hypothesis 1. In Hi-Lo games with incongruent cues, our model makes the yet unexplored prediction that labelling cues reduce coordination success. In Hi-Lo games with congruent cues, all our types choose the strategy leading to the payoff-dominant equilibrium irrespective of the presence of labelling cues. In Battle of the Sexes games, the mix of modes of reasoning is sufficient to make coordination more likely in the Closeness version than in the Spatially Neutral version. This replication of Isoni et al. (2013) is central to our investigation, as it motivates our interest in the Own and No Information games.

Hypothesis 1 *(FI games). With full information and $X < Y$:*

a) **(Hi-Lo games with incongruent cues):** *when players have the same preferences between equilibria and closeness is incongruent with payoffs, coordination success is lower in Closeness games than in Spatially Neutral games.*
b) **(Hi-Lo games with congruent cues):** *when players have the same preferences between equilibria and closeness is congruent with payoffs, coordination success is equal in Closeness games and Spatially Neutral games.*
c) **(Battle of the Sexes games):** *when players have conflicting preferences over equilibria, coordination success is higher in Closeness games than in Spatially Neutral games.*

In Own Information games, according to our model, the presence of focal-point reasoners is sufficient to improve coordination success in the Closeness version relative to the Spatially Neutral benchmark. Hence:

Hypothesis 2 *(OI games). With Own Information and $X < Y$, coordination success is higher in Closeness games than in Spatially Neutral games.*

Our model treats No Information games exactly as if they were Pure Coordination games. The fact that each player's payoff from coordination in the No Information case is a binary lottery giving X and Y with equal probability has no influence on our analysis. Thus:

Hypothesis 3 *(NI games). With No Information and $X < Y$, coordination success is higher in Closeness games than in Spatially Neutral games.*

We now turn to comparisons between Closeness games. In these comparisons, we focus on how coordination success varies between types of games with label salience but not joint-payoff salience. The first important comparison is between Pure Coordination and Battle of the Sexes. Because of the way in which level-k reasoning deals with conflict of interest,

[17] For all games except Battle of the Sexes, all the predicted probabilities shown in Table 2 would be unchanged if (as suggested in footnote 13) we used a cognitive hierarchy model in place of a level-k one, provided that level 0 is assumed to have zero probability. In all these games, the predicted behaviour of level-k reasoners is the same at each level 1, 2, ..., and so the best response to any one of these levels is the same as the best response to any probability mix of them. To arrive at cognitive-hierarchy predictions for Battle of the Sexes, all we need to do is to re-interpret $\rho(X,Y)$ as the probability that a randomly-selected cognitive-hierarchy reasoner chooses her Y strategy. The conclusion that $\rho^*(X,Y) \leq 0.5$ is unaffected.

our model predicts that coordination success will be lower in Battle of the Sexes than in Pure Coordination, in line with previous findings (e.g., Crawford et al., 2008; Isoni et al., 2013). This effect has two main causes: level-k reasoners have a tendency to discoordinate with each other (recall, $\rho^*(X, Y) \leq 0.5$), and the likelihood that players use focal-point reasoning $\varphi(X, Y)$ is weakly decreasing in the extent of the conflict of interest induced by the values of X and Y.

Hypothesis 4 *(Conflict of interest). With Closeness cues, coordination success is lower in Battle of the Sexes games than in Pure Coordination games.*

The next interesting comparisons are between information conditions. Our model makes predictions about how Own and No Information games compare with Pure Coordination and Battle of the Sexes: in terms of coordination success, the Own Information game should be intermediate between the two, while the No Information game should be equivalent to Pure Coordination. These are our final two hypotheses.

Hypothesis 5 *(Battle of the Sexes vs. OI games vs. PC games). In Own Information games with closeness cues:*

a) *coordination success is higher than in Battle of the Sexes games;*
b) *coordination success is lower than in Pure Coordination games.*

Hypothesis 6 *(NI games vs. PC games). In No Information games with closeness cues, coordination success is the same as in Pure Coordination games.*

A final aspect of our model that is relevant to our design is the effect of changing the payoff pair $\{X, Y\}$. This matters in Hi-Lo games via the function $\sigma(X, Y)$, and in Battle of the Sexes games via $\varphi(X, Y)$ and $\rho(X, Y)$. These effects are best seen in relation to participants' tendencies to claim the close or the more valuable disc. In Hi-Lo games, increasing the difference between X and Y makes it more likely that focal-point reasoners use joint-payoff salience, and so claim the disc worth Y to them. This only matters when label salience is incongruent with joint-payoff salience, reducing the probability that the close disc is claimed. In Battle of the Sexes, increasing the difference between X and Y has the effect of reducing the likelihood that players adopt focal-point reasoning, and hence claim the close disc. However, the effect on the behaviour of level-k reasoners can go in either direction, depending on the distribution of levels. So, the overall effect of changing the payoff pair in Battle of the Sexes games is not univocal.

4. Implementation

We recruited 118 participants from the general student population of the University of East Anglia (UK) using the ORSEE online recruitment system (Greiner, 2015). Participants who had already taken part in similar experiments were not allowed to sign up. The experiment was programmed in zTree (Fischbacher, 2007). Sessions took between 60 and 90 minutes to complete. The average payment was £11.26, including a £5 participation fee.

All participants faced the same thirty scenarios, in a sequence that was randomly determined for each individual. They were told that, for the duration of the experiment, they had been matched with an anonymous 'other person' in the room whose identity would never be disclosed. They knew that one of the thirty scenarios would be selected at the end of the experiment, and each player would be paid according to her decision and that of the matched person in the resulting game, plus the participation fee. While the instructions were read aloud, participants were guided through a number of practices about how to make and cancel their claims (see below), were shown a variety of examples illustrating what each player knew in each of the information conditions, and were asked to answer a comprehension questionnaire to ensure their full understanding of the experimental procedures. The experiment started after all participants had responded correctly to every question and any outstanding queries had been answered by an experimenter.[18]

In each of the thirty scenarios, participants went through a sequence of steps. They were first shown the location of the discs on the bargaining table (with their base shown at the bottom, as in Figs. 1 to 3), with both halves of the discs being empty, and told the values of X and Y (Step 1). If X and Y were different, they were next shown the four possible configurations of disc values (Step 2). One of these configurations would then be selected by the computer to be played, and presented in a separate screen with all halves of the two discs covered by question marks (Step 3).[19] The information condition was then revealed (Step 4). In the Full Information condition, all question marks were replaced by the corresponding disc values. In the Own Information condition, each player's own values were disclosed. In the No Information condition, all question marks stayed on the discs. Claims could then be made (Step 5).[20] If X and Y were equal, participants moved directly from Step 1 to Step 4, and the corresponding Pure Coordination scenario was shown straight away. Until the

[18] The full text of the instructions can be found in the Appendix.

[19] For the Full Information scenarios, the selection ensured that each participant faced all the scenarios implied by each disc value pair. For the Own Information and No Information scenarios, the computer randomly assigned the values of X and Y to each disc for each player.

[20] Sample screenshots of these steps can be found in the Appendix.

Table 3
Disc coordinates in Closeness and Spatially Neutral layouts.

Closeness (C) layouts	Close disc		Far disc		Match
	Column	Row	Column	Row	
LL	−2	−2	−2	2	RR
RR	2	−2	2	2	LL
LR	−2	−2	2	2	LR
RL	2	−2	−2	2	RL

Spatially neutral (N) layouts	Leftmost disc		Rightmost disc		Match
	Column	Row	Column	Row	
LL	−3	0	−1	0	RR
RR	1	0	3	0	LL
LR	−2	0	2	0	LR

claims for the current scenario were submitted, participants could move back and forth between Step 1 and Step 5 as they wished. After the decisions were submitted, the whole process was repeated for the next scenario in the series. There was no feedback between scenarios.

In each scenario, participants could claim discs by clicking on them. A claim on a disc was represented by a red line connecting it to the 'You' base, and by changing the disc colour from white to red. Any claim could be cancelled by clicking again on the disc, which would turn the disc white again and disconnect it from the 'You' base. Because there was no feedback during the experiment, each player could see only her own claims.

After all participants completed the thirty scenarios, each pair of matched participants' 'real' scenario, picked at random by the computer, was displayed on the screen together with both players' claims and actual disc values. These claims determined the participants' earnings.

The thirty scenarios used in the experiment were constructed using three pairs of disc values: $\{10, 10\}$, $\{10, 11\}$ and $\{6, 15\}$. There were two Pure Coordination scenarios (C1 and N1) for the $\{10, 10\}$ pair, and fourteen Full Information, Own Information or No Information scenarios (C2 to C8, and N2 to N8) for each of the $\{10, 11\}$ and $\{6, 15\}$ pairs.

Because all scenarios have just two discs, we introduced variety in the set of games faced by each participant by using different *layouts* of each scenario. These are detailed in Table 3, which reports the coordinates of each of the discs in each Closeness and Spatially Neutral scenario, as well as the layout seen by the 'Other' player (in the 'Match' column). Examples of these layouts are shown in Fig. 3 above; the full set of game configurations is reported in the Appendix.

In Closeness scenarios, the close disc was always in row −2 of the bargaining table (negative row numbers indicate rows on the 'You' side of the table), and the far disc was always in row 2. We varied whether the two discs were located in the same column to the left of the 'You' base (the LL layout), or in the same column to the right of that base (the RR layout), or one to the left and one to the right (the LR and RL layouts). Notice that each LL scenario can be matched with a corresponding RR scenario, and vice versa. LR scenarios are matches for each other, as are RL scenarios. In Spatially Neutral scenarios, both discs are necessarily in row 0 (the middle row of the table). We varied whether the two discs were located to the left of the 'You' base (the LL layout), to the right (the RR layout) or one to the left and one to the right (the LR layout). The LL layout is matched with the RR layout, and vice versa. The LR layout is a match for itself.

We counterbalanced the assignment of layouts to players so that each layout was faced by approximately the same number of participants. Each player experienced all possible layouts. Our expectation was that these variations in the positions of the discs would not have systematic effects on the relative strength of our spatial cues. This expectation was confirmed (see Section 5).

5. Results: summary statistics and coordination success metrics

The claims that players made in each scenario are summarised in Table 4. Since we found no systematic differences between responses to the different layouts of given scenarios, we pool across layouts when presenting our results.[21] For each of the three disc value pairs, $\{10, 10\}$, $\{10, 11\}$ and $\{6, 15\}$, the table contains a row for each pair of corresponding Closeness and Spatially Neutral scenarios. The class of each pair of scenarios (and the corresponding game for Full Information scenarios) is reported in the 'Class' column, with the information condition also reflected by the question marks in the scenario notation. For the Closeness scenarios, we report the frequencies of cases in which a participant claimed none of the discs, both discs, only the close disc or only the far disc, as well as the corresponding percentages (in parentheses). For

[21] We used Fisher's exact test to check whether different layouts of the scenarios resulted in different propensities to claim the close disc (in Closeness scenarios) or the leftmost disc (in Spatially Neutral scenarios). We found significant effects ($p < 0.05$) in just two of thirty comparisons (see the Appendix for details).

Table 4
Summary of claims by scenario.

Disc value pair	Class (Game)	Closeness scenarios					Spatially neutral scenarios				
		Configuration	None (%)	Both (%)	Close (%)	Far (%)	Configuration	None (%)	Both (%)	Left (%)	Right (%)
{10, 10}	PC	(10, 10)| |(10, 10)	4 (3)	3 (3)	101 (86)	10 (8)	|(10, 10) (10, 10)|	1 (1)	3 (3)	56 (47)	58 (49)
{10, 11}	FI (HL–I)	(10, 11)| |(11, 10)	1 (1)	3 (3)	32 (27)	82 (69)	|(10, 11) (11, 10)|	2 (2)	2 (2)	23 (19)	91 (77)
	FI (HL–C)	(11, 10)| |(10, 11)	1 (1)	3 (3)	103 (87)	11 (9)	|(11, 10) (10, 11)|	1 (1)	3 (3)	95 (81)	19 (16)
	FI (BS)	(10, 10)| |(11, 11)	2 (2)	4 (3)	91 (77)	21 (18)	|(10, 10) (11, 11)|	3 (3)	4 (3)	65 (55)	46 (39)
	FI (BS)	(11, 11)| |(10, 10)	2 (2)	2 (2)	73 (62)	41 (35)	|(11, 11) (10, 10)|	2 (2)	5 (4)	48 (41)	63 (53)
	OI	(10, ?)| |(11, ?)	0 (0)	4 (3)	57 (48)	55 (47)	|(10, ?) (11, ?)|	1 (1)	6 (5)	28 (24)	82 (69)
	OI	(11, ?)| |(10, ?)	1 (1)	3 (3)	95 (81)	21 (18)	|(11, ?) (10, ?)|	2 (2)	2 (2)	89 (75)	26 (22)
	NI	(?, ?)| |(?, ?)	3 (3)	4 (3)	88 (75)	23 (19)	|(?, ?) (?, ?)|	3 (3)	4 (3)	47 (40)	64 (54)
{5, 16}	FI (HL–I)	(5, 16)| |(16, 5)	2 (2)	2 (2)	17 (14)	97 (82)	|(5, 16) (16, 5)|	2 (2)	2 (2)	13 (11)	101 (86)
	FI (HL–C)	(16, 5)| |(5, 16)	0 (0)	2 (2)	104 (88)	12 (10)	|(16, 5) (5, 16)|	1 (1)	3 (3)	104 (88)	10 (8)
	FI (BS)	(5, 5)| |(16, 16)	2 (2)	4 (3)	68 (58)	44 (37)	|(5, 5) (16, 16)|	2 (2)	4 (3)	52 (44)	60 (51)
	FI (BS)	(16, 16)| |(5, 5)	1 (1)	4 (3)	78 (66)	35 (30)	|(16, 16) (5, 5)|	1 (1)	5 (4)	57 (48)	55 (47)
	OI	(5, ?)| |(16, ?)	2 (2)	5 (4)	31 (26)	78 (66)	|(5, ?) (16, ?)|	0 (0)	5 (4)	14 (12)	99 (84)
	OI	(16, ?)| |(5, ?)	1 (1)	1 (1)	109 (92)	9 (8)	|(16, ?) (5, ?)|	3 (3)	6 (5)	90 (76)	19 (16)
	NI	(?, ?)| |(?, ?)	3 (3)	6 (5)	87 (74)	22 (19)	|(?, ?) (?, ?)|	1 (1)	5 (4)	47 (40)	65 (55)

Notes: PC = Pure Coordination; FI = Full Information; OI = Own Information; NI = No Information; HL–I = Hi-Lo with Incongruent cues; HL–C = Hi-Lo with Congruent cues; BS = Battle of the Sexes.

Table 5
Summary of one-disc claims in Closeness games.

	{10, 10}
	Close disc
PC game *(Scenario C1)*	101/111 (0.91)

	{10, 11}		{5, 16}	
	Close disc	*Y* disc	Close disc	*Y* disc
FI games				
Hi-Lo with incongruent cues (Scenario C2)	32/114 (0.28)	82/114 (0.72)	17/114 (0.15)	97/114 (0.85)
Hi-Lo with congruent cues (Scenario C3)	103/114 (0.90)	103/114 (0.90)	104/116 (0.90)	104/116 (0.90)
Battle of the Sexes (Scenarios C4 and C5)	164/226 (0.73)	94/226 (0.42)	146/225 (0.65)	122/225 (0.54)
OI game *(Scenarios C6 and C7)*	152/228 (0.67)	150/228 (0.66)	140/227 (0.62)	187/227 (0.82)
NI game *(Scenario C8)*	88/111 (0.79)	n/a	87/109 (0.80)	n/a

Notes: The first entry in each cell is the number of cases in which only the close disc (respectively: the disc worth *Y*) was claimed; the second entry is the number of cases in which exactly one disc was claimed. The first number as a proportion of the second is shown in parentheses. The total number of relevant cases is 236 for the Battle of the Sexes and OI games and 118 for the other games. PC = Pure Coordination; FI = Full Information; OI = Own Information; NI = No Information; n/a = not applicable.

the Spatially Neutral scenarios, we report the equivalent information for none of the discs, both discs, only the leftmost disc and only the rightmost disc.[22]

It is immediately obvious from Table 4 that claims of none or both discs were very infrequent. Overall, 1.4 percent of responses claimed no disc and 3.1 percent claimed both.[23] Table 5 reports summary statistics, derivable from Table 4, about

[22] Because disc values were assigned at random in Own Information and No Information scenarios, roughly one quarter of the players faced two Own Information scenarios for each of the {10, 11} and {6, 15} payoff pairs in which the close (respectively, left) disc had the same value to them in both cases. These scenarios had, however, different layouts, so that the relative position of the two discs was different in the two instances. In Table 4, the frequencies (and percentages) for these cases contain two observations for these participants. Our statistical analysis takes this aspect of the data into account.

[23] Out of the 118 participants, 86 percent never made such claims, 88 percent made at most one, and 92 percent at most two. Thus, a minority of participants were responsible for the majority of the few dominated claims observed in the experiment.

the distribution of one-disc claims in Closeness games. In all Closeness games, each player saw one close disc and one far disc. For each of these games, Table 5 shows the proportion of one-disc claimants who claimed the close disc. Note that, if all participants ignored the spatial locations of the discs, this proportion would be 0.5 in all cases, except in Hi-Lo games, in which there is also a payoff cue which could skew claims in favour of the more valuable disc. In all FI games and in the OI game, each player saw one disc that she knew was worth Y to her and one disc that she knew was worth X, with $X < Y$. For each of these games, Table 5 also shows the proportion of one-disc claims in which the Y disc was claimed. Note that, if all participants ignored information about disc values, this proportion would be 0.5, except in Hi-Lo games, in which there is also a spatial cue which could skew claims in favour of the close disc.

The claims data in Table 4 allow us to check our convention of treating 'leftmost' (rather than 'rightmost') as the Spatially Neutral correlate of closeness (see Section 1). This convention would be problematic if rightmost was more or less salient than leftmost. We can test the relative salience of these two cues by looking at the distributions of one-disc claims in Spatially Neutral games. For example, consider the scenario N1. This represents a Pure Coordination game in which, for each player, one disc is leftmost and the other is rightmost. The null hypothesis that the two cues are equally salient implies that the two discs are claimed with equal probability. An analogous null hypothesis can be formed for scenario N8. A slightly different test can be applied to the pairs of scenarios {N2, N3}, {N4, N5} and {N6, N7}. For example, consider {N2, N3}. N2 represents a Hi-Lo game in which, for each player, the disc that is worth Y to her is leftmost. N3 differs only in that, for each player, the Y-valued disc is rightmost. The null hypothesis that the two cues are equally salient implies that the Y-valued disc is chosen with the same probability in both positions. The fifteen Spatially Neutral scenarios generate nine null hypotheses. None of these hypotheses can be rejected at the 10 percent significance level (using binomial or chi-squared tests). We conclude that it is safe to treat leftmost and rightmost as equally salient.

In order to assess the effect of spatial cues on the outcomes of our tacit bargaining games and in testing our hypotheses, we will use two metrics, each of which applies to games rather than scenarios: *mean expected coordination success* (MECS) and *mean expected payoff* (MEP). We now explain how these measures are defined and computed.

First note that, although each participant in our experiment was matched with just one of the other participants who took part in the same session, this matching was relevant only for determining final earnings. Because no feedback was given until the end of the experiment, there was no interaction between matched participants. Therefore, each player's *actual* coordination success and resulting payoff in any particular game, as determined by her decisions and those of her matched co-player, are not very useful for evaluating whether closeness cues had systematic effects on the outcome of the game. In order to assess these effects, we need measures that take into account the fact that each player was, in effect, playing against a population of potential co-players.

In computing MECS and MEP, we use a *legitimate matching procedure* analogous to the one used by Isoni et al. (2013). According to this procedure, for each of the scenarios that some player faced, she is matched, in turn, with all the other experimental players who faced scenarios compatible with their being in the position of the 'Other' person in that scenario. In our design, legitimate matches are entirely defined by the compatibility of scenarios (see 'Match' columns in Table 1) and the compatibility of layouts (see 'Match' column in Table 3). Note that legitimate matching requires that the disc value pair and the information condition are the same for each player and all her matches. So, for example, a player facing scenario C4 $= (X, X)| \, |(Y, Y)$ in the LL layout is matched, in turn, with all players (except herself) facing scenario C5 $= (Y, Y)| \, |(X, X)$ in the RR layout. A player facing scenario N6 $= |(X, ?) \, (Y, ?)|$ in the LR layout is matched, in turn, with all players (except herself) facing either scenario N6 $= |(X, ?)(Y, ?)|$ in the LR layout or scenario N7 $= |(Y, ?)(X, ?)|$ in the LR layout.

For any given game and for each participant, we can calculate the proportion of legitimate matches in which that participant would have successfully coordinated with the matched player. Successful coordination occurs when the two matched players' claims do not overlap.[24] MECS for that game is defined as the mean of this proportion, averaging over all participants. It has the useful feature that its maximum value, achieved in case of perfect coordination, is one, just like the probability of coordination in our model.

Similarly, we can calculate the average payoff each player would have got when playing the game, in turn, with each of her legitimate matches; MEP is the mean of these averages. The key difference between MEP and MECS is that MEP reflects the values of the discs that players claimed to achieve coordination, while this is not the case for MECS.

Table 6 reports MECS and MEP for each of the six types of game, separately for Closeness and Spatially Neutral versions of the games and for each relevant disc value pair.

In order to test Hypotheses 0 to 3, for each corresponding pair of matched Closeness and Spatially Neutral games, we use a bootstrap method to test whether MECS (respectively, MEP) differs between the two games.[25] This method works as follows. For each Spatially Neutral scenario, we repeatedly take random samples with replacement (with the sample size equal to the number of participants in the experiment, stratified over layout) from the actual observations for that game, and compute MECS (respectively, MEP) for each sample based on legitimate matching. We then compare the *actual*

[24] Successful coordination may occur in a number of ways. Players who claim no disc always successfully coordinate (but earn no money). Players who claim one disc successfully coordinate with all players who claim no disc and with those who claim only the disc they did not claim. Players who claim two discs successfully coordinate only with those who claim no disc. As noted above, the vast majority of claims were on exactly one disc.

[25] We use a bootstrap method because the computation of coordination indexes such as our MECS require us to repeatedly match participants with each other, which makes the expected coordination success for each participant not independent from those of other participants. A similar method is used in Bardsley et al. (2010). See the Appendix for details.

Table 6
Expected coordination success and expected payoffs in all games.

		{10, 10}	
		Closeness	Spatially neutral
PC game	MECS	0.8***	0.48
(Scenarios C1 and N1)	MEP	7.71***	4.69

		{10, 11}		{5, 16}	
		Closeness	Spatially neutral	Closeness	Spatially neutral
FI games					
Hi-Lo with incongruent cues	MECS	0.56***	0.66	0.73^{ns}	0.77
(Scenarios C2 and N2)	MEP	6.04***	7.09	11.12^{ns}	11.98
Hi-Lo with congruent cues	MECS	0.79**	0.69	0.78^{ns}	0.80
(Scenarios C3 and N3)	MEP	8.56**	7.45	12.45^{ns}	12.59
Battle of the Sexes	MECS	0.58***	0.47	0.52***	0.47
(Scenarios C4–C5 and N4–N5)	MEP	5.89***	4.74	5.32***	4.85
OI game	MECS	0.52***	0.48	0.51**	0.47
(Scenarios C6–C7 and N6–N7)	MEP	5.51***	5.02	6.96*	6.56
NI game	MECS	0.64***	0.50	0.62***	0.46
(Scenarios C8 and N8)	MEP	6.49***	4.96	7.08***	4.32

Notes: Asterisks show one-tail significance of MECS (respectively, MEP) in Closeness game relative to bootstrapped distribution of MECS (MEP) in corresponding Spatially Neutral game, as implied by our hypotheses: * = 10%, ** = 5%, *** = 1%; ns = not significant (or observed effect contrary to alternative hypothesis). PC = Pure Coordination; FI = Full Information; OI = Own Information; NI = No Information.

MECS (respectively MEP) computed using the legitimate matching procedure in the corresponding Closeness game with the bootstrapped distribution for the Spatially Neutral game. We conclude that MECS (respectively, MEP) is significantly different (in the predicted direction) between Closeness and Spatially Neutral games if the actual value of our statistic for the Closeness game falls above the 99th, 95th or 90th (or, in the case of Hypothesis 1a, below the 1st, 5th or 10th) percentile of the bootstrapped distribution for the Spatially Neutral game.[26] We use an analogous approach for comparisons between information conditions (Hypotheses 4 to 6), by deriving the bootstrapped distribution of MECS and MEP for the Pure Coordination and Battle of the Sexes games.[27]

6. Results: tests of main hypotheses

In this section, we focus on the formal tests of the hypotheses formulated in Section 3. For ease of exposition, and since MECS and MEP are very closely related, our discussion will concentrate on MECS, which maps onto our model more directly. For each hypothesis, patterns analogous to those discussed in relation to MECS apply to MEP.

6.1. Hypothesis 0: pure coordination games

To test Hypothesis 0, we compare MECS in the Closeness and Spatially Neutral versions of the Pure Coordination game. This game provides a benchmark for assessing the salience of the closeness cues built into our design. In the Closeness version, MECS is 0.80, which is much higher than the 0.48 recorded in the Spatially Neutral version. The difference is highly significant ($p < 0.01$; see Table 6), providing strong support to Hypothesis 0 and replicating Isoni et al.'s (2013) findings.

Behind this effect there are stark differences in the claims made by participants. In the Closeness version of this game, the close disc was claimed by 86 percent of players (and by 91 percent of those who made one-disc claims), while in the Spatially Neutral version claims were spread virtually equally between the leftmost and rightmost disc, confirming the expectation, built into our model, that neither leftness nor rightness would be label-salient (see Tables 4 and 5).

6.2. Hypothesis 1: full information games

In order to test Hypothesis 1, we compare the Closeness and Spatially Neutral versions of the Full Information Hi-Lo and Battle of the Sexes games.

[26] A casual look at Table 6 may reveal that even small differences in MECS may turn out to be strongly significant. This is because small differences in MECS may hide big differences in behaviour. For example, when the close disc is claimed by fifty percent of the players (and the far disc by the other fifty percent), MECS is 0.5 (i.e., $0.5^2 + 0.5^2$). When the close-far split is sixty-forty, MECS increases to just 0.52 (i.e., $0.6^2 + 0.4^2$). When it is eighty-twenty, MECS is 0.68 (i.e., $0.8^2 + 0.2^2$).

[27] The relevant percentiles of the bootstrapped distributions are reported in the Appendix.

According to Hypothesis 1a, in the Hi-Lo game with incongruent cues, coordination success should be lower in the Closeness version than in the Spatially Neutral version. This expectation is confirmed in the $\{10, 11\}$ payoff pair, for which MECS is 0.66 in the Spatially Neutral version and 0.56 in the Closeness version ($p < 0.01$). But for the $\{5, 16\}$ pair we do not find a significant difference, although the observed difference is in the predicted direction: MECS is 0.77 in the Spatially Neutral version and 0.73 in the Closeness version. So, Hypothesis 1a is only partly supported. A possible interpretation is that, in Hi-Lo games with large payoff differences between equilibria, joint-payoff salience is a much stronger cue than label salience.

According to Hypothesis 1b, there should be no difference in coordination success between the Spatially Neutral and Closeness versions of the Hi-Lo game with congruent cues. This is what we find in the $\{5, 16\}$ pair, where MECS is 0.78 with closeness cues and 0.80 without. But in the $\{10, 11\}$ pair we find that adding those cues significantly increases MECS from 0.69 to 0.79. Hypothesis 1b, like Hypothesis 1a, is only partly supported. Recall that Hypothesis 1b was derived under the simplifying assumption that players make no mistakes in implementing their strategies. That assumption leads to a prediction of perfect coordination, irrespective of the presence or absence of labelling cues. But if perfect coordination is not achieved, it is not surprising that congruent labelling cues can aid coordination, particularly when payoff differences between the Hi-Lo equilibria are small.

In all the Hi-Lo games, the majority of subjects (ranging from 69 to 88 percent of all claimants, and 72 to 90 per cent of one-disc claimants in the Closeness versions; see Tables 4 and 5) followed the payoff cue. In the Closeness versions, the percentage of one-disc claims on the more valuable disc is smaller in the $\{10, 11\}$ than in the $\{5, 16\}$ payoff pair, consistently with our model.

Hypothesis 1c is concerned with the effect of closeness cues in Battle of the Sexes games, in which there is conflict of interest between the two players. As predicted, those cues have systematic effects on coordination success. MECS increases from 0.47 in the Spatially Neutral game to 0.58 in the Closeness game in the $\{10, 11\}$ pair, and from 0.47 to 0.52 in the $\{5, 16\}$ pair. Both effects are statistically significant ($p < 0.01$), lending strong support to Hypothesis 1c.

The disc claims in Battle of the Sexes games also reveal some interesting patterns. 73 per cent of one-disc claims were on the close disc in the $\{10, 11\}$ game, 65 per cent in the $\{5, 16\}$ game (see Table 5). The relatively low coordination success in the $\{10, 11\}$ Battle of the Sexes game does *not* reflect a bias in favour of the Y-valued disc in players' claims. In the $\{10, 11\}$ game, only 42 per cent of one-disc claims were on that disc; the X-valued disc was frequently chosen in both locations (see Tables 4 and 5). On the other hand, the majority of one-disc claims (54 per cent) were on the more valuable disc when it was worth £16. This effect – a tendency for players in Battle of the Sexes games to choose the strategy that leads to their less-preferred equilibrium when payoff differences are small – has also been found by Crawford et al. (2008), who show that it can be induced by level-k reasoning.[28] Thus, behaviour in our Battle of the Sexes game is consistent with the assumption of our model that some players use focal-point reasoning and others use level-k reasoning.

6.3. Hypothesis 2: own information games

Hypothesis 2 is concerned with the Closeness and Spatially Neutral versions of Own Information games. For both pairs of disc values, coordination success is higher in the Closeness game than in the corresponding Spatially Neutral game. In the $\{10, 11\}$ payoff pair, MECS is 0.52 with closeness cues and 0.48 without ($p < 0.01$). In the $\{5, 16\}$ pair, it is 0.51 with closeness cues and 0.47 without ($p < 0.05$). These findings support Hypothesis 2.

Although all these MECS values are close to the random-choice benchmark of 0.5, the small differences we report correspond with quantitatively (as well as statistically) significant biases in individual behaviour (see footnote 26). In the Closeness version of the $\{10, 11\}$ game, 67 per cent of one-disc claimants claimed the close disc, and 66 per cent claimed the Y-valued disc. In the $\{5, 16\}$ game, the corresponding proportions were 62 per cent and 82 per cent (see Table 5). Notice that, consistently with our model, there are biases in favour of both the close disc (an implication of focal-point reasoning but not of level-k reasoning) and the Y-valued disc (an implication of level-k reasoning but not of focal-point reasoning).

6.4. Hypothesis 3: no information games

Hypothesis 3 predicts that coordination success will be higher in the Closeness versions of No Information games than in the Spatially Neutral versions. For both pairs of disc values, MECS clearly shows this pattern, increasing from 0.50 to 0.64 in the $\{10, 11\}$ pair ($p < 0.01$), and from 0.46 to 0.62 in the $\{5, 16\}$ pair ($p < 0.01$). Hypothesis 3 is strongly supported.

The Closeness versions of the No Information game are interesting in that, although players are made aware of *potential* conflicts of interest, they have no payoff information – not even private information – that can discriminate between the two strategies between which they have to choose. The only distinguishing properties are payoff-irrelevant cues. Clearly, those cues were used. Nevertheless, closeness cues were less powerful than when the Pure Coordination game was played with Full Information. As noted earlier, in the Closeness version of that game, the proportion of one-disc claimants who claimed the close disc was 0.91. The corresponding figure for the $\{10, 11\}$ No Information game is 0.79; for the $\{5, 16\}$ game 0.80.

[28] This effect weakens during the course of our experiment (see Appendix).

6.5. Hypothesis 4: the effect of conflict of interest

In both Pure Coordination and Battle of the Sexes games, labels provide the only useful way to break the symmetry between the two pure-strategy Nash equilibria. One of the observations that motivated our experiment is the finding that salient labels are used much less effectively in Battle of the Sexes games than in Pure Coordination games. This finding is clearly replicated in our data. MECS is 0.80 in the closeness version of the Pure Coordination game, but just 0.58 in the $\{10, 11\}$ and 0.52 in the $\{5, 16\}$ Battle of the Sexes game. Comparing the observed values of MECS in Battle of the Sexes games with the corresponding bootstrapped distribution for the Pure Coordination games, we find that all the differences are strongly statistically significant ($p < 0.01$).[29] This provides strong support for Hypothesis 4: conflicting preferences between coordination equilibria are detrimental to coordination success.

6.6. Hypotheses 5 and 6: comparing information conditions

The motivating idea behind our study is that the absence of common knowledge of payoffs – and therefore of whether or not there is conflict of interest – as in our Own Information and No Information games, would allow players to use focal-point reasoning more effectively than in Battle of the Sexes games. This is encapsulated in Hypotheses 5 and 6.

According to Hypothesis 5, coordination success in Own Information games should be intermediate between that of Pure Coordination and Battle of the Sexes. In the $\{10, 11\}$ Own Information game, MECS is just 0.52. In line with Hypothesis 5a, this value is clearly lower than the corresponding values in Pure Coordination games (0.80, $p < 0.01$). The same holds for the $\{5, 16\}$ game, in which MECS is 0.51 ($p < 0.01$). However, contrary to Hypothesis 5b, MECS is not higher in Own Information than in Battle of the Sexes games. In fact, in both payoff pairs, MECS is actually *lower* than in Battle of the Sexes (and significantly so in the $\{10, 11\}$ pair, $p < 0.05$). With respect to Own Information games, our model is failing to capture important aspects of behaviour.

The No Information games allow us to see if removing the last bit of exact payoff information restores the power of labelling cues to the level observed in Pure Coordination games, as predicted by Hypothesis 6. This is not the case. Although coordination success is relatively high in No Information games (MECS is 0.64 and 0.62 in the $\{10, 11\}$ and $\{5, 16\}$ payoff pairs), it falls short of the levels observed in the Pure Coordination game with the same cues. In both cases, the difference is statistically significant ($p < 0.01$). The effect reflects the greater proportion of one-disc claimants who claim the far disc in the No Information game (0.21 in the $\{10, 11\}$ and 0.20 in the $\{5, 16\}$ pair) than in the Pure Coordination game (0.09; see Table 5). Hypothesis 6 is not supported. We will consider possible explanations for the lack of support for Hypotheses 5 and 6 in the Conclusion.

7. Results: additional data analysis

7.1. Learning

Each participant in our experiment faced thirty scenarios, each of which represented a game between her and her matched participant. The order of these games was randomised independently for each participant, and there was no feedback between games. Under these conditions, each of our scenarios is strategically equivalent to a one-shot game between two players who make simultaneous moves. However, it is possible that, even without feedback, participants evolved particular strategies as a result of repeatedly facing games of a similar kind (e.g. Weber, 2003; Rick and Weber, 2010). For our purposes, this may be an issue if participants make different kinds of claims at different points of the experiment. We have explored this possibility and found no significant tendency for close discs to be claimed more or less often in Closeness scenarios as the experiment progressed, or for left (right) discs to be claimed more or less often in Spatially Neutral scenarios.[30]

7.2. Heterogeneity in behaviour

In Section 2, we presented our model as if all individuals were identical with respect to their inclination to adopt either kind of reasoning (as captured by the $\varphi(X, Y)$ function), to use the payoff cue in Hi-Lo games when using focal-point reasoning (the $\sigma(X, Y)$ function), or to claim the more valuable disc when using level-k reasoning (the $\rho(X, Y)$ function). This was done for expositional simplicity. In reality, individuals are likely to be heterogeneous in all these respects. In this section, we look at the extent of individual-level heterogeneity in relation to the issues that our experiment was designed to address.

As we pointed out in Section 2, the evidence that existed prior to our experiment cannot be explained by attributing focal-point and level-k reasoning to two distinct player types: it is necessary to assume that players are capable of using

[29] Because the payoff pairs differ between Pure Coordination and the other games, our comparisons between game classes are only done for MECS.

[30] We have also looked at learning in individual scenarios, and found no systematic effects, except for the tendency, mentioned earlier, to claim the far, less valuable disc in the $(Y, Y)|\ |(X, X)$ scenario less often later in the experiment. The details of these tests are reported in the Appendix.

both modes of reasoning, and that which mode is used at any time depends on the characteristics of the game being played. But one might expect that, if these characteristics are held constant, there will be some differences in individuals' propensities to use one mode rather than the other. We explore the magnitude of this effect by looking at individual-level behaviour across Closeness scenarios which involve the same X and Y payoffs, with $X < Y$. In each of the seven such scenarios for each payoff pair, there is a choice between a close and a far disc. We investigate whether, over the seven scenarios taken together, there is heterogeneity in participants' propensities to claim the close disc (an indicator of focal-point reasoning). In six of these scenarios for each payoff pair, there is a choice between a higher-valued and a lower-valued disc. We investigate whether, over these six scenarios taken together, there is heterogeneity in participants' propensities to claim the more valuable disc (an indicator of level-k reasoning).

We adapt the approach used by Faillo et al. (2017) and look at the extent to which observed behaviour departs from a benchmark that assumes that everybody has the same propensity to claim the close or the more valuable disc, keeping the payoff pair constant. Focusing on the 103 participants who claimed strictly one disc in every Closeness scenario, we can work out what the distribution of number of close claims (respectively, claims of the more valuable disc, when there was one) made by each individual in all relevant Closeness scenarios would look like if everyone were identical. For each relevant scenario, we use the observed proportion of close (more valuable) disc claims as the probability that any one individual claims the close (more valuable) disc in that scenario. We simulate the whole experiment (i.e., 103 decisions for each relevant scenario) 200 times, and derive the mean and 95% confidence intervals of such *benchmark* distributions. We do this separately for each of the two payoff pairs, and compare the cumulative benchmark distribution with the *actual* cumulative distribution of number of close (more valuable) claims made by the participants in the experiment. These comparisons are reported in Fig. 4.

Fig. 4a reports the distributions of close claims. Given that there was often a trade-off between claiming the close and the more valuable disc, and that the more valuable disc was more attractive in the $\{5, 16\}$ disc value pair than in the $\{10, 11\}$ pair, it is not surprising that close claims were less common in the former pair than in the latter. For both payoff pairs, the actual and benchmark cumulative distributions of close claims are very similar, but there are some signs of heterogeneity, especially for the $\{5, 16\}$ pair. We conduct a formal statistical test by looking at whether the variance of the actual distribution differs significantly from the variance of the benchmark distribution. For the $\{10, 11\}$ pair, the actual variance is 1.68, which exceeds the 95th percentile (1.60) of the variance of the benchmark distribution. In the $\{5, 16\}$ pair, the actual variance of 1.73 exceeds the 99th percentile (1.72) of the variance of the benchmark distribution. Overall, not surprisingly, there is more variability in participants' propensity to claim the close disc than there would be if everybody were identical, but the effect is quantitatively small.

A similar picture emerges from Fig. 4b, which looks at high value claims. Unsurprisingly, the more valuable disc was claimed more often in the $\{5, 16\}$ pair than in the $\{10, 11\}$ pair. For both pairs, the variance of the actual distribution exceeds the 99th percentile of the corresponding benchmark distribution. As in the case of close claims, there is more variability than could be expected with identical individuals, but the differences are not dramatic.[31] Signs of moderate heterogeneity are visible across information conditions. The likelihood of claiming the close disc in one of the four Own Information scenarios or one of the two No Information scenarios increases in the number of close claims made in the Full Information scenarios. Also, having made more high value claims in the Full Information condition is associated with a higher probability of claiming the high value disc in the Own Information condition.[32] Similarly, claiming the close (respectively, high value) disc in a given $\{5, 16\}$ scenario is associated with claiming the close (high value) disc in the corresponding $\{10, 11\}$ scenario.[33]

An overall reading of this evidence is that there are individual-level differences in participants' propensities to use each mode of reasoning – an aspect of behaviour that our model abstracts from. But the evidence does not suggest that individuals can usefully be divided into discrete types, defined by modes of reasoning: most participants use focal-point reasoning in some games and best-response reasoning in others.

8. Conclusion

Schelling (1960) suggested that rational players are capable of adjusting their mode of reasoning to the problem they are facing, and that game theory should take that into account to make more accurate and relevant predictions. Schelling's intuition about the use of focal-point reasoning to resolve coordination problems has now been proven correct for situations in which players' interests are perfectly aligned. It has also become clear that players are less likely to use focal-point reasoning when there is common knowledge that coordination requires the resolution of conflicts of interest. But questions remain as to how the transition between focal-point and best-response reasoning occurs. We have addressed this question by focusing on the, arguably highly realistic, situations in which players do not have precise information about the payoffs of a game.

Our initial conjecture was that, in the absence of full information about the payoffs of a game, players would give relatively more attention to payoff-irrelevant features of the game and so be more likely to use focal-point reasoning. In

[31] Extreme 'types' were rare. Only 4 participants claimed the close disc in all fifteen Closeness scenarios; just 3 claimed the more valuable disc in all the twelve Closeness scenarios in which it was possible to do so.

[32] See the random effects probit regressions reported in the Appendix.

[33] See Tables A.4 and A.5 in the Appendix.

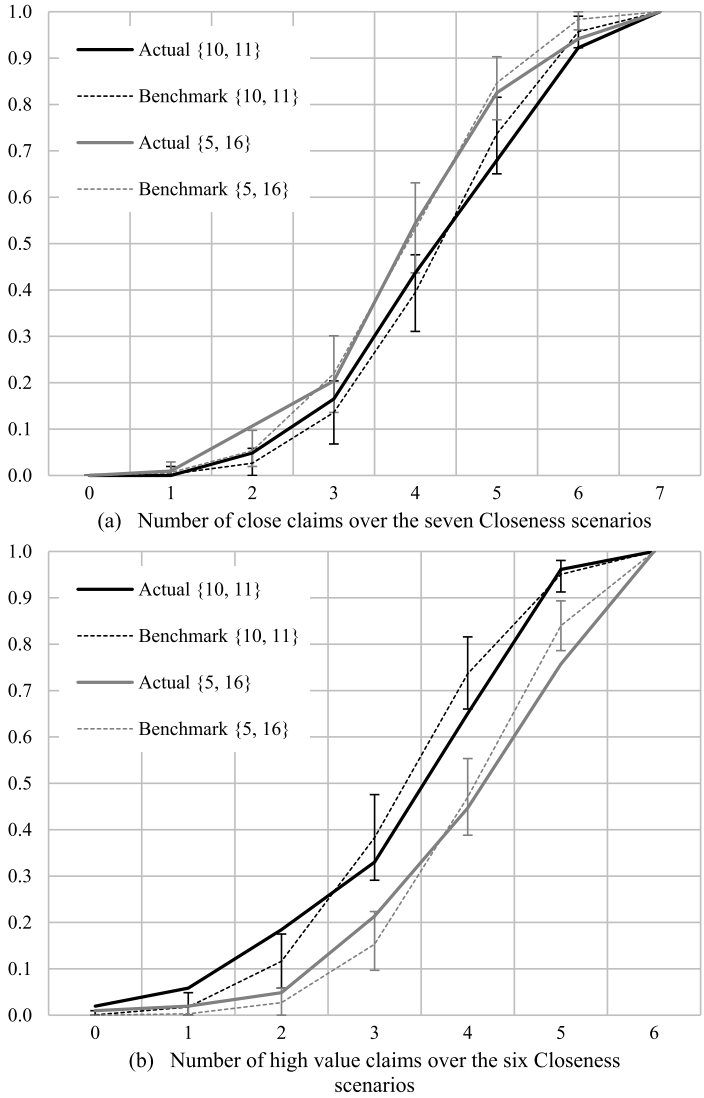


Fig. 4. Cumulative distributions of close and high value disc claims by individual.

the model that we developed to represent this conjecture, we assumed that focal-point reasoning would be inhibited by conflicts of interest only if those conflicts were common knowledge. Our findings do not support that conjecture.

In both our new conditions, the lack of perfect payoff information seems to make focal-point reasoning less likely than when all payoffs are known. The effect is perhaps more dramatic in the Closeness versions of the Own Information games, where coordination success was *less* than in the corresponding Battle of the Sexes game, and where the majority of participants claimed the disc that was more valuable to them. If both players follow this strategy, an equilibrium is reached, but that equilibrium (in which coordination is achieved with a probability of only 0.5) is payoff-dominated by the [*Close*, *Close*] equilibrium attainable by focal-point reasoning. Choosing the more valuable disc in this game seems to be most naturally explained as the result of best-response reasoning, such as that described by level-k theory. In the Closeness versions of the No Information games, there seems to be no reason for players to claim the far disc. It is noteworthy that such claims (although always infrequent) were more common in the No Information game than in the Pure Coordination game. This finding suggests that players' reasoning may have been more subject to error in the No Information game.

In suggesting explanations for why our initial conjecture was not supported, we move into the domain of *post hoc* speculation. In that spirit, we offer two possible and complementary explanations. The first uses the idea, discussed in Section 2, that focal-point reasoning is associated with group identification, and that conflicts of interest inhibit group identification. It may be that the mere awareness of *potential* conflicts of interest is sufficient to reduce players' sense of being a collective 'we'. For example, in the No Information condition, players know that one of them might be advantaged relative to the other, even though they do not know who this would be. The second explanation starts from the fact that more information has to be assimilated and processed by players of Own Information and No Information games than by

players of Pure Coordination games. For example, a No Information game is strategically equivalent to a Pure Coordination game, but recognising that equivalence is not a trivial task. If players treat best-response reasoning as their default mode of thinking about games, more complicated games will be less likely to induce focal-point reasoning. For example, a player who feels uncertain about the situation she is facing in an Own Information game might fall back on the thought (represented by level-1 reasoning in level-k theory) that if her opponent were equally likely to choose either strategy, the best she could do would be to claim the higher-valued disc.

Common to both these explanations is the idea (fundamental to the analysis of team reasoning in Bacharach, 2006) that transitions between best-response and focal-point reasoning are not fully determined by factors that are represented in theories of rational choice: psychological factors play a crucial role. Understanding these factors remains an important challenge for behavioural game theory.

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Appendix A. Supplementary material

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.geb.2019.01.008.

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