

# **Compound Games, focal points, and the framing of collective and individual interests.**

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## Abstract

This study introduces the game theoretical concept of “compound games” and investigates whether the decomposition of a game influences behaviour. Specifically, we investigate whether separating battle of the sexes games into a pure coordination component and the remaining battle of the sexes component changes coordination success. The literature attributes high coordination rates in pure coordination games with focal points to team reasoning and low coordination rates in related battle of the sexes games to level- $k$  reasoning. We find that coordination success in compound games depends on the decomposition and order of component games, suggesting that collective interests are fragile in the presence of opposing individual interests. Our results show that compound games are empirically relevant; we discuss a wide range of possible applications for compound games.

**Keywords:** Compound games, focal points, framing, collective interest

**JEL Codes:** C72, C91, D90

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# 1 Introduction

Consider the battle of the sexes game between a Bach admirer and a Stravinsky enthusiast regarding the evening entertainment on 21 March 2020. “Their main concern is to go out together, but one person prefers Bach and the other person prefers Stravinsky” (Osborne and Rubinstein, 1994, p. 15). Of course, both aficionados know that the evening happens to be on Bach’s 335th birthday.

In this paper, we ask whether the coordination success of the two music devotees can be increased by emphasising the pure coordination element of the game “to go out together”? In more applied settings, this questions translates into whether one could accelerate, for example, the Brexit negotiations or US-China trade negotiations by emphasising those individual negotiation elements with aligned interests.

We investigate this question with the help of the new concept of compound games. The example in table 1 shows the decomposition of a battle of the sexes game ( $BS$ ) into a compound game  $pc+bs$  consisting of a pure coordination component ( $pc$ ) and the remaining battle of the sexes component ( $bs$ ). Similar to the description quoted above and basically any verbal description of a  $BS$  game, this decomposition formally separates the motive “to go out together” from the second motive that “one person prefers Bach and the other person prefers Stravinsky”.

$$\begin{array}{c|cc} & B & S \\ \hline B & 11, 10 & 0, 0 \\ S & 0, 0 & 10, 11 \end{array} = \begin{array}{c|cc} & B & S \\ \hline B & 4, 4 & 0, 0 \\ S & 0, 0 & 4, 4 \end{array} + \begin{array}{c|cc} & B & S \\ \hline B & 7, 6 & 0, 0 \\ S & 0, 0 & 6, 7 \end{array}$$

Table 1: Decomposition of  $BS$  game into compound game  $pc + bs$ .

Experimental evidence shows that in pure coordination games ( $PC$ ) payoff-irrelevant salient features – such as Bach’s birthday – allow players to coordinate with a success rate higher than predicted by random choice (Mehta et al., 1994; Bardsley et al., 2010; Isoni et al., 2013; Sitzia and Zheng, 2019). This success is commonly explained with the theory of team reasoning, which is based on Schelling’s (1960) theory of focal points, and postulates that both players look for a selection rule that maximises the chances of coordination when both act in line with that rule (Sugden, 1995; Bacharach, 2006). In recent years, this literature has furthermore established that this success is severely reduced in battle of the sexes games due to the players’ conflicts of interest. The frequent mis-coordination is attributed to level- $k$  reasoning, in which label or payoff salience shape level-0 players’ behaviour (Crawford et al., 2008; van Elten and Penczynski, 2020).

Generally, our proposed decomposition – theoretically a mere re-framing of the game – raises the question of whether behaviour will be different. In our application, this question translates into whether a more explicit framing of the two motives increases or decreases the coordination success. Also, given that the two components are separated, does the order of presentation or

a possible sequence of presentation matter? In other words, is the overall mode of reasoning influenced by the nature of the first or second component game rather than the original simple game? Would it matter that the second component is only visible after a provisional choice in the first? Furthermore, given that the decomposition is not unique and that a different common interest component could be separated, does the size of the separated *pc* payoff influence the success of coordination?

In recent years, various game decompositions have been introduced to the literature (Candogan, Menache, Ozdaglar and Parrilo, 2011; Kalai and Kalai, 2013; Jessie and Saari, 2013; Demuynck, Seel and Tran, 2019). These decompositions have been mostly used for theoretical and diagnostic purposes, such as quantifying the competitiveness of a game (Demuynck et al., 2019). Our decomposition is motivated by the richer, yet formal representation of a game and by its potential behavioural relevance.

To our knowledge, we are the first to empirically study behaviour in decomposed games. This becomes feasible and well-defined thanks to the new game theoretic concepts of aggregation and disaggregation of games. We define “Cartesian games” as games that consist of multiple games, which we call “component games”. We define a “compound game” as a game of multiple component games with identical strategy spaces for all of which players are constrained to play identical strategies. In some respects, we introduce the game analogue to framing lotteries as simple, compound, and reduced lotteries.

Our results show that the game decomposition has an influence on behaviour. Coordination success in compound games increases if a *pc* component game is presented first and decreases when the first game is a *bs*. Decomposing a simple *PC* game into two *bs* components reduces coordination success significantly. Even in Cartesian games, a *bs* component game reduces the coordination success in the subsequent *pc* component game.

The nature of these results relates our study to the literature on narrow bracketing and behavioural spillovers. Decomposing a game gives rise to the possibility that players narrow bracket; they consider component games in isolation and fail to see the compound game as a whole (Read, Loewenstein, Rabin, Keren and Laibson, 1999). Like the literature finds narrow bracketing in independent lottery choices (Tversky and Kahneman, 1981; Rabin and Weizsäcker, 2009), we find narrow bracketing in our Cartesian games. Surprisingly, while compound games’ strategy space highlights the simultaneous relevance of the two component games, the effects of narrow bracketing are even stronger than in our Cartesian games. Behavioural spillovers imply that the adoption of one behaviour causes another related behaviour (Bednar et al., 2012). We see interesting asymmetric spillovers as a *bs* component influences a following *pc* component much more than vice versa.

While simple games can summarise concisely multiple aspects of strategic situations, com-

pound and Cartesian games are able to formally capture aspects of a framing that might arise naturally in the interaction and thus relate to the verbal or mental representation of a game. For example, complex negotiations will naturally be considered by topic before parties come to an overall agreement. As in the related field of compound lotteries (Kahneman and Tversky, 1979), the behavioural consequences to this framing are shown to be significant and relevant. Compound games bear the potential to analyse games in detail and break them down into fundamental, cognitively irreducible elements.

## 2 Literature

### 2.1 Decompositions

The last 10 years have seen the emergence of a sizeable set of theoretical studies that propose decompositions of games for different purposes. These papers have mostly used the decomposition for theoretical and diagnostical purposes, not for empirical studies of behaviour as we propose.

In a prominent contribution, Kalai and Kalai (2013) decompose any 2-player game with finitely many strategies into a competitive zero-sum game and a cooperative common-interest game. They use the decomposition to define a semi-cooperative solution, the coco value, for games with transferable utility.

Demuyne et al. (2019) extend this decomposition to games with an arbitrary number of players and an infinite strategy space. With an appropriate metric, they define the normed distance between any game and its cooperative component as the competitiveness-cooperativeness index (CCI). In the empirical part of the paper, they show that the competitiveness of behaviour in experimental games is on average in line with the CCI.

Jessie and Saari (2013) introduce a unique decomposition of  $n$ -player, binary strategy games into 3 parts, a strategic, a behavioural and a Kernel (non-strategic) part.<sup>1</sup> One main contribution of this decomposition is the reduction of complexity in the analysis of a game. Building on this decomposition, Jessie and Kendall (2015) show that the invariance to the behavioural and non-strategic part – which many equilibrium concepts and models of strategic thinking feature – is not observed empirically.

Our study provides empirical support for the relevance of Jessie and Saari’s decomposition because moving from a pure coordination game to a battle-of-the-sexes game introduces non-zero entries in the “behavioral” component game. Furthermore, once the concrete implementation of a decomposition is considered, we see that the order and the timing of a unique decomposition

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<sup>1</sup>The strategic part contains all information to determine a strategic outcome while the behavioural part captures the game’s aspects that can lead to other kinds of analysis, such as side payments, social preferences, etc.

matter and can introduce differing outcomes for the same decomposition.

Candogan et al. (2011) introduce a flow representation of finite games in strategic form, which is used for a decomposition of an arbitrary game into its potential, harmonic and nonstrategic components. A game is said to be a potential game if the incentive of all players to change their strategy can be expressed using a single global function called the potential function (Monderer and Shapley, 1996).

## **2.2 Coordination games with focal points and modes of reasoning**

To investigate behaviour in compound games we employ pure coordination and battle of the sexes games with focal points. These games present an interesting case study because observed behaviour is found to be sensitive to whether players' preferences are aligned or conflicting with respect to which equilibria to coordinate on. No theory as of yet is able to fully organise the experimental evidence.

Coordination games present a problematic class of games for standard game theory because of its inability to select one equilibrium out of the many possible ones. In his seminal work, Schelling (1960) proposes a theory of focal points in which players are able to concert their expectations on some salient features of the game (e.g. salient labels attached to strategies) and coordinate on one particular equilibrium, the focal point of the game. Schelling's theory has been further developed by Sugden (1993) and Bacharach (2006) under the name of team reasoning. These theories assume that players think of themselves as being part of a team (collective rationality). In Bacharach's theory, when players team-reason they ask the question "what should we do" and work out a strategy profile, the best rule in Sugden's theory, that leads to the best possible outcome for the team and dictates what each player should do.

Using a variety of pure coordination games, abundant experimental evidence consistent with team reasoning has been collected over the years. For example, Mehta et al. (1994) employ a series of matching games in which subjects are asked to name an object (flower, city, etc.) or to choose an object out of many. Crawford et al. (2008) find similar results employing a pie game and an XY-game. The pie game is a two-player game with three pure Nash equilibria while the allocation game features two. Isoni et al. (2013) use a bargaining table in which players have to agree on how to share a monetary surplus by making claims on some valuable "discs".

The promising success of team reasoning theories in explaining behaviour in pure coordination games however is greatly reduced when players' interests are not aligned, such as in the battle of the sexes games. Crawford et al. (2008) develop a model of level- $k$  thinking that is able to explain the low coordination success observed in these games. This type of reasoning is fundamentally different and incompatible with team-reasoning, as it implies an individualistic type of reasoning

in which players anchor their beliefs on the behaviour of a player that lacks strategic sophistication, a level-0 player, and best respond to that.

Since Crawford et al. (2008), attempts have failed to show that team reasoning is the prevalent mode of reasoning employed across the whole range of coordination games (e.g. Bardsley et al., 2010; Isoni et al., 2013). Empirical evidence has instead shown that individuals seem to be using both types of reasoning depending on the features of the coordination games. Specifically, conflicts of interest seem to inhibit team-reasoning and evoke individualistic reasoning while absence of conflict facilitate collective reasoning (Faillo et al., 2017; van Elten and Penczynski, 2020).

Compound games provide insights that are indicative of the extent to which modes of reasoning can be influenced and of whether one of the two modes of reasoning is more fragile.

## 2.3 Narrow bracketing and behavioural spillovers

When facing multiple choices at the same time, individuals often consider each choice in isolation and fail to appreciate the consequences of those choices collectively. Narrow bracketing is a well-documented phenomenon in the literature of individual decision-making under risk (Read et al., 1999). A clear instance is offered in the study by Tversky and Kahneman (1981), later replicated by Rabin and Weizsäcker (2009). Specifically, from choices between lotteries A and B as well as C and D, only 3 percent choose combination BC. Yet, the majority chooses BC over AD when these lottery pairs are presented in aggregate.

Bland (2019) finds evidence of narrow bracketing in a Cartesian game of two Volunteer's dilemmata at the individual but not at the aggregate level. Our study, although not designed as a controlled test of narrow bracketing, adds clear evidence of this phenomenon in compound and Cartesian games. Most apparently, in a  $bs + bs$  decomposition of a  $PC$  game, subjects seemingly do not integrate outcomes because the coordination success is lower than in the  $PC$  game.

While the concept of narrow bracketing focuses on the differences between the game and its decomposed equivalents, the concept of behavioural spillovers considers changes in behaviour in a game due to preceding games. In a sequence of games, behavioural spillovers might be the result of a positive transfer of a principle, rule or strategic behaviour from one game to another one (Knez and Camerer, 2000; Cooper and Kagel, 2005, 2008; Haruvy and Stahl, 2012; Mengel and Sciubba, 2014). For example, Cooper and Van Huyck (2018) provide experimental evidence of transfer of the principle of dominance from stag hunt games to order statistic games such as the weak-link game or median games. In the absence of feedback, our study provides an example of asymmetric "rule spillover". Our results are in line with the explanation that the mode of strategic reasoning is carried over from  $bs$  to  $pc$  components, but not vice versa.

To the extent that these spillovers are inefficient, they can be seen as a type of behavioural

inertia (Bednar et al., 2012; Liu et al., 2019). In these studies on inefficient spillovers, defection is observed more frequently when the Prisoner’s Dilemma is played with a Self-Interest game than when it is played in isolation. This literature predominantly observes such inertia from games with clearly favoured actions to games with more distributed action profiles (Cason et al., 2012). Here, we see the opposite as the inertia is most pronounced when moving from the low coordination *bs* components to the higher coordination *pc* components.

### 3 Cartesian, compound and reduced games

The experimental implementation of decomposed games requires suitable concepts to talk about the aggregation and disaggregation of games as well as differences between modes of aggregation. In some respects, these concepts will be analogous to the aggregation and disaggregation of lotteries in compound and reduced lotteries. As a starting point, we establish the simple game<sup>2</sup> as the elementary basis for further manipulations.

**Definition 1 (Simple game)** *A simple game consists of a finite set of players  $i \in N$  and a strategy space  $S = \times_i S_i$ . The preferences of player  $i$  are represented by a payoff function  $\pi_i : S \rightarrow \mathbb{R}$ .*

	<u>A</u>	A
<u>A</u>	11, 10	0, 0
A	0, 0	10, 11

Table 2: A simple 2-player *BS* (11, 10) with  $S_i = \{\underline{A}, A\}$ .

The most basic way of aggregating games – in other words, formalizing play of multiple games – is to represent the simultaneous play of a number of simple games in what we call a Cartesian game. Cartesian games have occasionally been implemented in the experimental literature but not formally defined (e.g. Bland, 2019); they are a natural auxiliary games in this study of compound games.<sup>3</sup>

**Definition 2 (Cartesian game)** *A Cartesian game  $\Gamma$  consists of a totally ordered set  $C$  of  $c$  simultaneously played simple component games, all of which feature the same finite set of players  $i \in N$ . Each component game features a strategy space  $S^c$  and payoff functions for players  $i$ ,  $\pi_i^c : S^c \rightarrow \mathbb{R}$ .*

<sup>2</sup>In cooperative game theory, games that feature only payoffs of 0 or 1 are called simple games. Here, we merely want to distinguish a game from a compound game.

<sup>3</sup>Our concept of Cartesian game nests the two concepts commonly referred to as “supergame”. In the study of repeated games, a “supergame” refers to a possibly infinite number of sequential repetitions of a simple stage game, which is a sequential version of a Cartesian game with identical component games. In experimental economics, the term “supergame” is often used to emphasise that one experimental session, in which participants play more than one game – be it simultaneously or sequentially – might therefore feature additional unintended strategic considerations beyond the individual component games.



Table 3 presents an exemplary Cartesian game. Generally, we denote component games in lowercase as  $pc$  and  $bs$ , respectively. A Cartesian game with two  $pc$  component games is denoted  $pc \times pc$ , where the first term refers to component 1 and the second to component 2. In order to be able to distinguish a  $pc \times bs$  game from a  $bs \times pc$  game with identical component games – as is necessary in any implementation – the definition uses a totally ordered set  $C$ .

	$a$	$b$			$\alpha$	$\beta$
$a$	7, 6	0, 0	$\times$	$\alpha$	4, 4	0, 0
$b$	0, 0	6, 7		$\beta$	0, 0	4, 4

Table 3: Cartesian game  $bs(7, 6) \times pc(4, 4)$ .

Reduced to a simple game, the Cartesian game can be represented as a game with the eponymous strategy space  $\Sigma = \times_c \times_i S_i^c$  and a payoff function for player  $i$ ,  $\sum_c \pi_i^c = \Pi_i^\Gamma : \Sigma \rightarrow \mathbb{R}$ , as table 4 illustrates.

	$a\alpha$	$a\beta$	$b\alpha$	$b\beta$
$a\alpha$	11, 10	7, 6	4, 4	0, 0
$a\beta$	7, 6	11, 10	0, 0	4, 4
$b\alpha$	4, 4	0, 0	10, 11	6, 7
$b\beta$	0, 0	4, 4	6, 7	10, 11

Table 4: Reduced form of Cartesian game  $bs(7, 6) \times pc(4, 4)$ .

In contrast to the way in which a Cartesian game relates to its component games, all decompositions in the literature as well as our experimental design feature the same strategy space in the component games as in the reduced game. Furthermore, the strategies for the different component games are not meant to be chosen independently by players, but rather are set to be the same across all component games. It is therefore useful to define a compound game as follows.

**Definition 3 (Compound game)** *A compound game  $G$  consists of a totally ordered set  $C$  of  $c$  simultaneously played simple component games, all of which feature identical sets of players  $N$  and strategy spaces  $S$ . The outcome  $s \in S$  is constrained to be the same across all  $c$  component games. Each component game features payoff functions for player  $i$ ,  $\pi_i^c : S \rightarrow \mathbb{R}$ .*

Table 5 gives an example of a compound game. A compound game with two  $pc$  component games is denoted  $pc + pc$ . In the reduced form of a compound game, for each player and each outcome  $s \in S$  the payoff is equal to the sum of payoffs in the component games:  $\pi_i^G = \sum_C \pi_i^c$ . Table 6 shows the exemplary reduced compound game.

	<u><math>a</math></u>	$b$			<u><math>a</math></u>	$b$
$a$	7, 6	0, 0	+	$a$	4, 4	0, 0
$b$	0, 0	6, 7		$b$	0, 0	4, 4

Table 5: Compound game  $bs(7, 6) + pc(4, 4)$ .

	<u><math>aa</math></u>	$bb$
$aa$	11, 10	0, 0
$bb$	0, 0	10, 11

Table 6: Reduced form of the compound game  $bs(7, 6) + pc(4, 4)$ .

## 4 Experimental design and procedures

Our experiment involves 31 games (simple, compound, and Cartesian) inspired by the  $XY$ -game in Crawford et al. (2008). In this game, two players are required to choose one out of two strategies. In our experiment, strategies are labelled by the resulting payoff allocation in the case of coordination. One of the strategies is made salient by underlining it. If players choose the same strategy then the allocation is enforced, otherwise they earn nothing.

- You receive £a the other receives £b
- You receive £b the other receives £a

In a pilot experiment, underlining one of the strategies has proved to be a more powerful cue for coordination than using  $X$  and  $Y$ . As simple games, we implemented one  $PC$  game, in which  $a = b$ , and two  $BS$  games, in which  $a > b$ . The payoff matrices for these games are reported in table 7. In line with the experiment's framing, the strategies have been labelled as A and  $A$ .

	<u>A</u>	A
<u>A</u>	10, 10	0, 0
A	0, 0	10, 10

(a)  $PC$  (10, 10).

	<u>A</u>	A
<u>A</u>	11, 10	0, 0
A	0, 0	10, 11

(b)  $BS$  (11, 10)

	<u>A</u>	A
<u>A</u>	12, 9	0, 0
A	0, 0	9, 12

(c)  $BS$  (12, 9)

Table 7: Implemented simple games.

For our purposes, a simple game is decomposed into  $\#C = 2$  component games, component 1 and component 2. The simple  $PC$  game is decomposed either into two  $PC$  games ( $pc + pc$ ) or two  $BS$  games ( $bs + bs$ ). The simple  $BS$  games is decomposed into one  $pc$  game and one  $bs$  game (see table 8). Table 9 lists all simple and non-simple games that we employed.

We implement two treatments, the treatment  $COMP$  that features the basic framing of a compound game and the treatment  $PART$  that is intended to further emphasise this framing. The

$$\begin{array}{c} \underline{A} \\ A \end{array} \begin{array}{cc} \underline{A} & A \\ 11, 10 & 0, 0 \\ 0, 0 & 10, 11 \end{array} = \begin{array}{c} \underline{A} \\ A \end{array} \begin{array}{cc} \underline{A} & A \\ 7, 6 & 0, 0 \\ 0, 0 & 6, 7 \end{array} + \begin{array}{c} \underline{A} \\ A \end{array} \begin{array}{cc} \underline{A} & A \\ 4, 4 & 0, 0 \\ 0, 0 & 4, 4 \end{array}$$

Table 8: Decomposition of  $BS$  into compound game  $bs+pc$ .

Simple Games	Compound/Cartesian games			
	$pc \cdot pc$	$bs \cdot bs$	$pc \cdot bs$	$bs \cdot pc$
$PC(10, 10)$	$0, 0 \cdot 10, 10$	$1, 0 \cdot 9, 10$		
	$4, 4 \cdot 6, 6$	$3, 0 \cdot 10, 7$		
	$7, 7 \cdot 3, 3$	$4, 3 \cdot 7, 6$		
	$9, 9 \cdot 1, 1$	$5, 2 \cdot 5, 8$		
	$10, 10 \cdot 0, 0$	$7, 5 \cdot 3, 5$		
		$7, 6 \cdot 3, 4$		
$BS(11, 10)$			$0, 0 \cdot 11, 10$	$11, 10 \cdot 0, 0$
			$4, 4 \cdot 7, 6$	$7, 6 \cdot 4, 4$
			$7, 7 \cdot 4, 3$	$4, 3 \cdot 7, 7$
			$10, 10 \cdot 1, 0$	$1, 0 \cdot 10, 10$
$BS(12, 9)$			$0, 0 \cdot 12, 9$	$12, 9 \cdot 0, 0$
			$4, 4 \cdot 7, 5$	$7, 5 \cdot 4, 4$
			$7, 7 \cdot 5, 2$	$5, 2 \cdot 7, 7$
			$9, 9 \cdot 3, 0$	$3, 0 \cdot 9, 9$

Notes: The games  $pc(0, 0)$  and  $bs(1, 0)$  have different equilibrium features than standard  $pc$  and  $bs$  games, respectively.

Table 9: Implemented simple, compound and Cartesian games (outcomes of the equilibrium  $\underline{AA}$  in each component game reported). The dot  $\cdot$  stands for  $+/ \times$ .

emphasis is achieved by varying the amount of information subjects have when making decisions in component 1.

In the complete information treatment *COMP* we implement simple and compound games. In this treatment, the component games are presented on the screen at the same time. Players have therefore complete information of the entire compound game when deciding which strategy to select. Component 1 is always displayed at the top of the screen and component 2 at the bottom.

In the partial information treatment *PART* we implement simple, compound and Cartesian games. In this treatment, the component games are presented on the screen one after the other, thus strengthening the framing of compound games with separated and sequential component games. In compound games, when the individual components are presented sequentially, decisions in component 1 are made under partial information, as payoffs of component 2 are not yet displayed. Of course, players are allowed to change the strategy they have selected in component 1 once they are presented with component 2. However, as players know that decisions in component 1 are not binding, to minimise the risk of players not engaging with those choices, *PART* also implements Cartesian games. Therefore, when facing a component 1, players do not know whether that is the component 1 of a compound game, the component 1 of a Cartesian game, or a simple game. They are informed of this after they select a strategy.<sup>4</sup> Because of this uncertainty, decisions in this component will be treated as binding with some probability, as players will not be able to change it in Cartesian or simple games. Having both the compound and the Cartesian versions of the same component games implies a *PART* treatment with twice as many games as the *COMP* treatment. To have a comparable number of games in both treatments, *PART* features two sub-treatments: *PART<sub>a</sub>* and *PART<sub>b</sub>*. Each sub-treatment features only half of the compound games in *COMP* with the remaining half implemented as Cartesian games. The compound games in *PART<sub>a</sub>* are implemented as Cartesian games in *PART<sub>b</sub>*, and vice versa. Component games are chosen so that in both *PART<sub>a</sub>* and *PART<sub>b</sub>* there is an equally numerous representation of  $pc + pc$ ,  $bs + bs$ ,  $pc + bs$ , and  $bs + pc$  for each simple game employed.

We do not implement Cartesian games in *COMP* as our objective is to investigate the behavioural relevance of compound games. Cartesian games are instrumental to the achievement of this objective. However, our results show that, in fact, these games offer some unique insights into behaviour that are complementary to those offered by compound games. As such, they should be object of further investigations either on their own or in conjunction with compound games.

The experiment was run in the AWI laboratory at the University of Heidelberg (Germany) in July 2018. We recruited 148 subjects with the online system hRoot (Brock 2004): 46 subjects in

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<sup>4</sup>In order to identify games in the experiment, the instructions employ a more user-friendly terminology: “linked” allocations for compound games, “unlinked” allocations for Cartesian games, and “allocations” for simple games. Instructions are reprinted in appendix 7.

the *COMP* treatment and 102 subjects in the *PART<sub>a</sub>* and *PART<sub>b</sub>* treatments. Upon arrival, subjects were handed the experimental instructions that were read aloud by the experimenter. Subjects then answered a brief questionnaire to check their understanding of the experiment. When all participants were ready the experiment started. The order of the games was randomised across participants. Feedback was only provided at the end for one randomly selected game that was then used to determine the experimental earnings. In addition, subjects were given a participation fee of €5. Average earnings were about €10.38.

## 5 Hypotheses

In this section we will derive hypotheses for our games using a combination of team reasoning (Bacharach, 2006; Schelling, 1960; Sugden, 1995) and level- $k$  thinking (Crawford et al., 2008). Following Isoni et al. (2019), we will assume that players are capable of using both modes of reasoning, although only one at a time.

The simple games feature two players  $i = \{1, 2\}$  and two strategies  $s = \{\underline{A}, A\}$ . Strategies are uniquely labelled with one label per strategy, one of which is salient ( $\underline{A}$ ). By virtue of this labelling, one strategy stands out. If players choose the same strategy, which is equivalent to choosing a label, their payoffs are  $\pi_{is} \in \{a, b\}$  (with  $a \geq b > 0$ ) and zero otherwise. The simple games are used to derive compound games. These games consist of two component games  $c = \{1, 2\}$ , each with two strategies  $s(c) \in \{\underline{A}, A\}$ . Players are required to choose the same strategy in both games.

We say that two players team-reason if they independently look for a rule that, if followed by both, will lead to the best possible outcome for the team. In the games we employ, this rule is to choose the strategy whose label is salient, that is  $s = \underline{A}$ .

The version of the level- $k$  model in Crawford et al. (2008) assumes that players differ in their level of strategic sophistication. Level-0 players ( $L0$ ) have a payoff bias, in that they choose, with a probability  $p > 0.5$ , the strategies whose equilibria have a higher own-payoff. If both equilibria have the same own-payoff,  $L0$  choose according to label salience with probability  $p > 0.5$ . Higher levels anchor their beliefs on the behaviour of  $L0$  and best-respond to players just one level below theirs.  $L1$  best-respond to  $L0$ ,  $L2$  to  $L1$  and so on. The distribution of levels in the population is exogenously given and  $L0$  only exist in the mind of other players.  $L1$  in a *PC* will therefore always choose the label salient strategy  $s = \underline{A}$ , as the probability of coordination is greater than one half. All levels greater than  $L1$  will best-respond by choosing the same strategy. In *BS* games, how often the label salient strategy is chosen depends on the distribution of levels. For our purposes, without making any further assumption, it suffices to say that  $s = \underline{A}$  will be chosen less frequently than in a *PC* game.

Following Isoni et al. (2019), let us define the probability that a player uses team-reasoning

as  $\tau$ . The probability that a player uses level- $k$  reasoning is  $\kappa = 1 - \tau$ . If we consider the whole population of players, this probability can be interpreted as a proportion.

We assume that the class of game, be it a simple or a component game, influences these probabilities. For a *PC* game, where  $a = b$ , experimental evidence suggests that team reasoning is more prevalent than level- $k$  reasoning, therefore  $\tau_{PC} > \kappa_{PC}$ . By contrast, level- $k$  thinking is more prevalent in *BS* games, therefore  $\kappa_{BS} > \tau_{BS}$  (van Elten and Penczynski, 2020). We take this to further imply that  $\tau_{PC} > \tau_{BS}$ .

**Hypothesis 1 (Simple games)** *The frequency of choice of the salient strategies is greater in the simple PC than in the simple BS games.*

We will derive predictions for the reasoning in the compound games with the help of three assumptions, two specifying the determinants of the mode of reasoning and one specifying exactly which game is reasoned about.

The first assumption spells out how the class of the component games (*pc* or *bs*) influence the probability  $\tau$ . By the virtue of being displayed on top of the screen in *COMP* and first in *PART*, we assume that component 1 has a stronger influence on the mode of reasoning than component 2.

**Assumption 1 (Class of component game)** *The probability of the type of reasoning employed,  $\tau$ , is a function of the class of the pivotal component game. The pivotal component game is component 1 with probabilities  $0.5 < p_{COMP} < p_{PART} = 1$ .*

By the nature of our decomposition of a given *BS* game, a higher payoff in a *pc* component leaves unchanged the absolute difference between players' payoffs in the *bs* component. This difference therefore increases in *relative* terms as the *pc* payoff rises. Intuitively, a higher *pc* payoff and a larger relative payoff difference in *bs* possibly impact the type of reasoning in opposite directions. At this stage, although we are aware that payoff sizes might be empirically relevant Paravano and Poulsen (2015), we assume for simplicity no effect of differently sliced decompositions. Our experiment is however designed to be able to falsify this assumption.

**Assumption 2 (Component game payoffs)** *For any two compound games with the same reduced form game and with the same ordered classes of component games, different payoffs in the component games do not have any effect on the mode of reasoning.*

Assumption 3 asserts that subjects integrate the payoffs of the component games and reason about the reduced game.<sup>5</sup>

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<sup>5</sup>Alternatively, one could assume that the reduced game determines the mode of reasoning. However, this would lead to hypotheses that do not distinguish between any compound games derived from the same simple game. Assuming that subjects do not integrate payoffs could be a valid alternative, but would require further assumptions about the determination of the one action to be played in all component games.

**Assumption 3 (Integration)** *The mode of reasoning is applied to the reduced compound game.*

On the basis of these assumptions, the next two hypotheses spell out the most basic implications of decomposing simple games into a compound game.

**Hypothesis 2 (PC decomposition)** *Decomposing a PC game into  $pc + pc$  or  $bs + bs$  does not change the frequency of choice of the salient strategy.*

Applied to the reduced PC game due to integration, both modes of reasoning predict the same level of salient strategy choices.

**Hypothesis 3 (BS decomposition)** *In COMP, decomposing a BS game into  $bs + pc$  or  $pc + bs$  increases the frequency of choice of the salient strategy. In PART the frequency of choice increases only if the BS game is decomposed into  $pc + bs$  but not otherwise.*

In COMP, because the first component game is assumed to be more important for the mode of reasoning, a  $pc$  component 1 leads to more frequent team reasoning and salient choices. A  $bs$  component 1 lead to more level- $k$  reasoning. In PART, because component 2 does not influence modes of reasoning, a  $bs$  component 1 implies the same behaviour as in a simple BS game.

**Hypothesis 4 (BS order)** *Decomposing a BS game into  $bs + pc$  will lead to a lower frequency of choice of the salient strategy than in  $pc + bs$ .*

Compared to  $pc + bs$ , the  $bs$  component 1 makes team reasoning and thus salient choices less frequent in  $bs + pc$ .

**Hypothesis 5 (Cartesian)** *In Cartesian games, the salient strategy is chosen in components  $pc$  and  $bs$  as often as in simple PC and BS games, respectively.*

In Cartesian games, players are not constrained to choose the same strategy in both component games. Games are independent and – under assumption 2 on neutral effects of component game payoffs – predictions in the individual component games  $pc$  and  $bs$  are the same as those in the simple PC and BS games, respectively.

From the perspective of narrow bracketing, the relevance of the components for the mode of reasoning can be viewed as the result of not viewing the compound game as a whole but paying attention to individual components. According to our assumptions, this partial view only influences the choice of mode of reasoning, which is in turn applied to the compound game in its reduced form. Compared to COMP, the PART treatment can be seen as a manipulation that prompts narrow bracketing by displaying the component games one by one.

## 6 Results

In a battle of the sexes game, whether a simple or a component one, we define player 1 ( $P1$ ) as the player whose payoff is higher in the focal point and player 2 ( $P2$ ) as the other player. For the  $bs+bs$  compound game, we let component 1 define  $P1$ . It follows that  $P1$  has the lower own-payoff in the focal point equilibrium in the second  $bs$  component game. The reverse is true for  $P2$ . We use the same definitions of players in the Cartesian games.

### 6.1 The simple games

Table 10 shows that the choice frequency of the salient strategy is as expected significantly greater in the  $PC$  game than in both  $BS$  games (McNemar test, on pooled  $COMP$  and  $PART$  data;  $p < 0.001$  for  $PC$  vs.  $BS(11, 10)$ ,  $p < 0.001$  for  $PC$  vs.  $BS(12, 9)$ ). In the simple  $BS$  games, both players choose less often the salient strategy, but the reduction is more pronounced for  $P2$ .

Treatment	Players	$PC$	$BS$	
			(11, 10)	(12, 9)
$COMP$	<i>All</i>	0.826	0.630	0.478
	$P1$	–	0.696	0.522
	$P2$	–	0.565	0.435
$PART$	<i>All</i>	0.843	0.608	0.647
	$P1$	–	0.706	0.765
	$P2$	–	0.510	0.529

Table 10: Fractions of salient strategy choices in the simple games  $PC$  and  $BS$  by treatment and player type.

**Result 1 (Simple Games)** *The choice frequency of the salient strategy is greater in  $PC$  than in the two  $BS$  games.*

### 6.2 Component game payoffs

In the derivation of the hypotheses, assumption 2 states that behaviour in compound games is not influenced by the specific payoff size of each individual component. This assumption is directly testable in our experiment, which features up to four different payoff decompositions per  $BS$  game. As the assumption on payoff size is only critical in deriving the hypotheses in compound games with both  $pc$  and  $bs$  components, we restrict our analysis to  $BS$  decompositions.



	<i>COMP</i>			<i>PART</i>		
	<i>All</i>	<i>P1</i>	<i>P2</i>	<i>All</i>	<i>P1</i>	<i>P2</i>
<i>pc</i> payoff	0.031 (0.022)	0.041* (0.023)	0.021 (0.027)	-0.027* (0.015)	-0.024 (0.019)	-0.031 (0.019)
Period	0.003 (0.002)	0.006* (0.003)	0.001 (0.003)	0.000 (0.002)	0.000 (0.003)	-0.001 (0.003)
<i>bs</i> + <i>pc</i>	-0.021 (0.022)	-0.015 (0.028)	-0.028 (0.026)	-0.118*** (0.032)	-0.020 (0.045)	-0.215*** (0.043)
<i>BS</i> (12, 9)	-0.004 (0.024)	0.041 (0.041)	-0.049 (0.030)	0.039 (0.053)	0.069 (0.054)	0.010 (0.070)
<i>N</i>	736	368	368	816	408	408

*Notes:* Logit regression with standard errors clustered at the subject level. The variable *pc* payoff is categorised as follows: 1 = (0, 0); 2 = (4, 4), 3 = (7, 7), 4 = (10, 10) or (9, 9). Significance levels: \*  $p < 0.10$ , \*\*  $p < 0.05$ , and \*\*\*  $p < 0.01$ . *N*: Number of observations.

Table 11: The effect of the size of the *pc* payoffs on fractions of salient strategy choices.

Table 11 reports the results of a logit regression with clusters at the subject level. The dependent variable is a binary variable that takes value one if the salient strategy is chosen and zero otherwise. The independent variables are the size of the *pc* payoffs (“*pc* payoff”), “Period”, “*bs* + *pc*” which takes value one if *bs* is either placed at the top the screen in treatment *COMP* or displayed first in treatment *PART* and zero otherwise, “*BS*(12, 9)” which takes value one if the compound game reduces to the simple *BS* with payoffs (12,9) in the focal equilibrium and zero otherwise.

We estimate six models: three per treatment. “*All*” considers all the treatment’s data, “*P1*” and “*P2*” only player 1 and player 2’s data, respectively. The estimated coefficient of “*pc* payoff” is positive and marginally significant in *COMP* for *P1* and negative and marginally significant in *PART* for *All*. The order of the components is relevant in *PART*, and affects significantly only the behaviour of *P2*; the next section will come back to this result. “Period” of play is weakly significant in *COMP* for *P1*. Overall, these results do not show a systematic influence of the *pc* payoff and are thus supportive of our modelling assumption 2.

### 6.3 The compound games

Table 12 reports the proportion of salient strategy choices for all compound game types by treatment and player type. Because our main concern is whether behaviour differs across these four compound game types, we focus on averages without distinguishing whether they reduce to the simple *BS*(12, 9) or to the simple *BS*(11, 10).

*PC Decomposition.* We expect behaviour in *pc* + *pc* and *bs* + *bs* not to differ from that in the simple *PC* game, given that we assume integration of the component game payoffs and that team

Treatment	Players	<i>PC</i>		<i>BS</i>		Simple <i>BS</i> Average
		$pc + pc$	$bs + bs$	$bs + pc$	$pc + bs$	
<i>COMP</i>	<i>All</i>	0.865	0.743	0.598	0.614	0.554
	<i>P1</i>	–	0.783	0.723	0.728	0.609
	<i>P2</i>	–	0.703	0.473	0.500	0.500
<i>PART</i>	<i>All</i>	0.843	0.634	0.581	0.699	0.627
	<i>P1</i>	–	0.778	0.730	0.750	0.735
	<i>P2</i>	–	0.490	0.431	0.647	0.520

*Notes:* The column “Simple *BS* Average” shows the average fraction of salient strategy choices in *BS*(11, 10) and *BS*(12, 9). In a *BS* game, *P1* is the player whose payoff is higher in the focal point. In  $bs + bs$ , *P1* is identified in component 1.

Table 12: Fractions of label salient choices in the compound games by treatment and player type.

reasoning and level- $k$  reasoning both predict a salient choice in *PC*. We find evidence in support of this hypothesis only for the compound game  $pc + pc$  in both treatments (Wilcoxon signed-rank test,  $p = 0.783$  in *COMP* and  $p = 0.601$  in *PART*). Instead, for the  $bs + bs$  decomposition, we observe in both treatments a statistically significant reduction in salient strategy choices compared to the simple *PC* (Wilcoxon signed-rank test,  $p = 0.064$  in *COMP* and  $p < 0.001$  in *PART*).

**Result 2 (*PC* decomposition)** *In both COMP and PART, the choice frequency of the salient strategy is significantly lower in  $bs + bs$  than in PC.*

This result suggests that players do not fully integrate outcomes, in contrast to assumption 3. In *COMP* however, the fact that the frequency of salient strategy choices in  $bs + bs$  is significantly greater than that in *BS* (Wilcoxon signed-rank test,  $p = 0.015$  in *COMP* and  $p = 0.081$  *PART*), suggests that something akin to partial integration is going on. In *PART*, on the other hand, the sequential display seems to prevent such a process from happening altogether.

Note that the lower frequency of salient strategy choices in  $bs + bs$  compared to that in the simple *PC* is mainly influenced by the behaviour of *P2* and to a lesser extent by that of *P1*. This is consistent with the assumption that component 1 has a stronger effect on behaviour than component 2 in both treatments but especially in *PART*. Because *P2*s have a lower own-payoff in the focal point equilibrium of component 1, they choose the salient strategy less often than the non-salient one. Specifically, in *PART* the salient strategy is chosen 49% of the times and this selection is changed in the second *bs* only about 12% of the times, even when it should be clear that the compound game reduces to a simple *PC*. This type of behaviour is compatible with some kind of decision inertia, or behavioural spillovers, but it is also possible that once players are distracted

by the conflict of interest in the first *bs*, attention to label salience is lost when the second *bs* is unveiled. This result is also consistent with narrow bracketing.

*BS Decomposition.* Table 12 shows that in *COMP* the mere decomposition of a *BS* into a compound game featuring a *pc* component does lead to an increase, albeit not significant, in the choice frequency of the salient strategy compared to the simple *BS* (Wilcoxon signed-rank test,  $p = 0.305$  for  $bs + pc$  vs. *BS*, and  $p = 0.191$  for  $pc + bs$  vs. *BS*). In *PART*, only in  $pc + bs$  subjects choose more frequently this strategy. In the  $bs + pc$  decomposition this strategy is, in fact, chosen less often (Wilcoxon signed-rank test,  $p = 0.014$  for *BS* vs.  $pc + bs$ ,  $p = 0.055$  for *BS* vs.  $bs + pc$ ).

**Result 3 (BS Decomposition)** *In COMP, the BS decomposition does not have a significant effect on the frequency of salient strategy choices compared to a simple BS. In PART instead, we do find that this frequency increases in the pc + bs decomposition and decreases in the bs + pc one.*

The *BS* decomposition in *COMP* does not have the hypothesised significant effect of highlighting the common interests in coordination via the *pc* component. For this decomposition to be effective, *PART*'s stronger emphasis of the component 1 is needed. An implication of this finding, consistent with the literature on focal points, is that the mere information, as in *COMP*, on the presence of a *bs* component influences behaviour more than the knowledge of the presence of a *pc* component. In *PART*'s  $pc + bs$ , subjects' stronger exposition to the *pc* component makes their behaviour more in line with simple *PC* games.

*BS Order.* Hypothesis 4 states that the order, in which component games are presented, influences how often the salient strategy is chosen. We do find that this is indeed the case in both treatments, but the effect is statistically significant only in *PART* (Wilcoxon signed-rank test for  $pc + bs$  vs.  $bs + pc$ ,  $p = 0.694$  in *COMP* and  $p < 0.001$  in *PART*).

**Result 4 (BS Order)** *Decomposing a BS game into bs + pc leads to a lower choice frequency of salient strategy than in pc + bs in PART, while no difference is observed in COMP.*

The difference in salient strategy choices between  $bs + pc$  and  $pc + bs$  is mainly driven by the behaviour of subjects in the role of *P2*. *P2*s choose the salient strategy only 43% of the times when the *bs* component is played before the *pc* one. Instead, they choose it significantly more when *bs* is displayed afterwards (Wilcoxon signed-rank test for  $pc + bs$  vs.  $bs + pc$ ,  $p = 0.539$  for *P1*,  $p < 0.001$  for *P2*).

## 6.4 The Cartesian games

Table 13 reports proportions of salient strategy choices in Cartesian games by game type and component. Cartesian games feature only in *PART* and differ from compound games in that players' actions are not constrained.

Both components of the Cartesian game  $pc \times pc$  show choice frequencies of salient strategies above 80%. In line with our predictions, these frequencies are not significantly different from those observed in the simple  $PC$  game (Wilcoxon sign-rank test,  $p = 0.104$  and  $p = 0.724$  for  $PC$  vs.  $pc1$  and  $pc2$  respectively). Similarly, the choice frequency in each individual component of  $bs \times bs$  is not statistically different from the average frequency observed in the simple  $BS$  games (Wilcoxon sign-rank test,  $p = 0.694$  and  $p = 0.963$  for average  $BS$  vs.  $bs1$  and  $bs2$  respectively). These results are also supportive of assumption 2 on the component game payoffs.

Players	$pc \times pc$		$bs \times bs$		$pc \times bs$		$bs \times pc$	
	$pc1$	$pc2$	$bs1$	$bs2$	$pc1$	$bs2$	$bs1$	$pc2$
All	0.807	0.846	0.578	0.598	0.853	0.603	0.591	0.716
$P1$	–	–	0.791	0.464	0.868	0.779	0.750	0.804
$P2$	–	–	0.366	0.732	0.838	0.426	0.431	0.627

Notes:  $pc1$  and  $bs1$  are the component games displayed first;  $pc2$  and  $bs2$  are the component games displayed after.

Table 13: Proportion of salient strategy choices in Cartesian games by component game and player.

In both Cartesian games  $pc \times bs$  and  $bs \times pc$ , subjects choose significantly more often the salient strategy in the  $pc$  component than in the  $bs$  one (Wilcoxon signed-rank test,  $p < 0.001$ ). In addition, the choice frequency in  $pc$  is significantly greater in  $pc \times bs$  than in  $bs \times pc$  (Wilcoxon signed-rank test,  $p < 0.001$ ). This difference is mainly driven by  $P2$ 's behaviour. When the  $pc$  component is displayed before the  $bs$  one,  $P2$ s choose the salient strategy 83.8% of the times. When the  $pc$  component is displayed after the  $bs$  one, the choice frequency drops to 62.7% (Wilcoxon signed-rank test,  $p < 0.001$ ). As a consequence, the choice frequency in the  $pc$  component is significantly different from that in the simple  $PC$  if the  $pc$  component is displayed after the  $bs$  one but not vice versa (Wilcoxon signed-rank test,  $p < 0.001$  for  $pc2$  vs.  $PC$  in  $pc \times bs$  and  $p = 0.233$  for  $pc1$  vs.  $PC$  in games and  $bs \times pc$ ).

For both Cartesian games  $pc \times bs$  and  $bs \times pc$ , the choice frequency of the salient strategy in the  $bs$  component is not significantly influenced by the displaying sequence (Wilcoxon signed-rank test,  $p = 0.491$ ). In line with our predictions, the choice frequency of the salient strategy in the  $bs$  components is not significantly different from the average frequency observed in both  $BS$  games (Wilcoxon signed-rank test,  $p = 0.285$  for  $bs1$  vs.  $BS$  and  $p = 0.963$  for  $bs2$  vs.  $BS$ ).

**Result 5 (Cartesian games)** *The salient strategy is chosen as often in  $bs$  games as it is in the simple  $BS$  games. In  $pc$  games the salient strategy is chosen as often as in the simple  $PC$  games when it is not displayed after a  $bs$  component.*

## 6.5 Summary

The results of our first application of compound games provide evidence of their relevance in understanding behaviour. In particular, our experiment shows that game decompositions lead to differences in behaviour that are influenced not only by whether the component games are independent, as in Cartesian games, or linked, as in compound games, but also by the order in which they are displayed.

Cartesian games provide evidence of stronger behavioural spillovers from a *bs* component to a *pc* than from a *pc* to a *bs* one. This suggests that behaviour consistent with level-*k* reasoning is more persistent than behaviour compatible with team reasoning. In other words, in this instance, the collective mode of reasoning is more fragile than the individualistic one and hinders possible learning transfers from the *pc* component to the *bs* one.

Compound games provide evidence of narrow bracketing in that a decomposition of a *PC* into a *bs* + *bs* game leads to a decrease in salient strategy choices compared to a *pc* + *pc* decomposition. Although the two *bs* components reduce to a simple *PC*, once opposed motives are highlighted by the first *bs* component, they cannot be reconciled by the second *bs* component. Although, theoretically, players' interests in a *bs* + *bs* compound game are aligned, behaviourally that game is closer to a battle of the sexes game, seemingly because outcome integration is only partially carried out. The sequential component display implemented in *PART* is not necessary for this decomposition to alter behaviour, which, to a lesser extent, is also observed in the *COMP* treatment as well.

Finally, our experiment shows that the sequential display implemented in *PART* makes the influence of component 1 more determinant for behaviour than that of component 2, as if, once subjects engage in the type of reasoning triggered by that first component, that reasoning or behaviour cannot be forgotten but spills over to the second component.

## 7 Outlook and conclusion

The *BS* compound games in our study are examples of decompositions *by motive*. These decompositions have the potential to relate more closely than simple games to both verbal and, possibly, mental representations of strategic situations. These compound games can be formal representations of verbalised motives and thus language-independent tools that could be employed to study, for example, cross-cultural differences in games and motives. This formal representations can also help scrutinise the relationship between games and their verbal account. For example, the separation of a *BS* game into two motives, provided in the introduction, clarifies the description's failure to motivate the zero payoffs off the diagonal. For a complete verbalisation of the *BS* normal form

game, a third sentence and component should reflect that “all music is equally unenjoyable<sup>6</sup> when consumed alone”.

Compound games might become a useful diagnostic tool to assess the empirical strength of a motive. If, for example, the behaviour in simple and associated compound games is different, the required payoff change in one component to equate behaviour in the simple and compound games is informative about the relative strength attributed to the motives in the original simple game.

Decompositions by motive could lead to the definition of a finite set of behaviourally elementary component games. These games would be irreducible to more elementary cognitive motives, lead to shortest possible verbalisations, possibly invoke specific types of reasoning as do *pc* and *bs*, and might simplify the game comprehension despite the multiple components. Beyond a set of motives, it is not difficult to think of decomposing games by additional sets of motives, by player, by cell, or even randomly, which could lead to further interesting applications.

As one example of such applications, consider the compound Prisoner’s Dilemma game in table 14. This decomposition is not by motive but *by cell* and isolates two elementary *PD* components: the Hi-Lo (*hl*) component that identifies the benefits from cooperation and the off-diagonal *bs* component that identifies the “temptation” from defection. Would such a decomposition increase cooperation?

	Cooperate	Defect		<i>C</i>	<i>D</i>		<i>C</i>	<i>D</i>
Cooperate	4, 4	1, 5	=	<i>C</i>	4, 4   0, 0	+	<i>C</i>	0, 0   1, 5
Defect	5, 1	2, 2		<i>D</i>	0, 0   2, 2		<i>D</i>	5, 1   0, 0

Table 14: Decomposition of *PD* into *hl+bs*.

In contrast to Cartesian games, important properties of component games such as dominance-solvability and Nash equilibria do not necessarily find analogues in the reduced form of a compound game. In table 14, iterated deletion of dominated strategies leads to the strategy pair (*D*, *D*) in the reduced game, but is not applicable to any of the component games. In compound games, the defining requirement to play the same strategy across components allows players to exchange binding commitments to strategy *D*, even though neither component game has *D* as unique equilibrium strategy.<sup>7</sup>

The goal of this paper was to introduce the theoretical concept of compound game and – with an application informed by the literature on focal points – to investigate whether these games are behaviourally meaningful. We find that salient choices are more frequent in a *PC* game than in its *bs* + *bs* compound game and that separating a *pc* component in a *BS* game is effective only when the *pc* component is displayed first. Furthermore, our results suggest that, for the decompositions

<sup>6</sup>Or should we say “bland”? Or “vapid”? Is “zero” an adjective?

<sup>7</sup>We are indebted to Bob Sugden for these considerations.

we employ, heuristics such as narrow bracketing and behavioural spillovers can help rationalise observed behaviour. We believe that this paper’s contributions can be further developed to study behaviour in different contexts, to provide a formal analysis of verbal descriptions of simple games, and to encompass different kinds of decompositions.

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## Appendix A - Experimental instructions

Below are the instructions for both treatments *COMP* and *PART*. The paragraphs that are treatment specific are enclosed in square brackets, written in italics and preceded by the treatment in which they appear.

### Introduction

This is an experiment in the economics of decision-making. If you follow the instructions and make appropriate decisions, you can earn an appreciable amount of money. You will receive your earnings for today's session in cash before you leave the laboratory.

It is important that you remain silent and do not look at other people's work. If you have any questions, or need assistance of any kind, please raise your hand and an experimenter will come to you. If you talk, laugh, exclaim out loud, etc., you will be asked to leave and you will not be paid. We expect and appreciate your cooperation.

We will now describe the session in more detail. Please follow along with these instructions as they are read aloud.

Everyone in the room is receiving exactly the same instructions.

Only treatment *COMP*:

*[You will be presented with thirty (30) different scenarios, one after the other. Each scenario is an interaction between you and another person. Everyone in the room will make decisions in the same 30 scenarios.]*

Only treatment *PART*:

*[You will be presented with thirty-one (31) different scenarios, one after the other. Each scenario is an interaction between you and another person. Everyone in the room will make decisions in the same 31 scenarios.]*

At the end of the experiment, the computer will randomly pair you with another person in the room and one of the scenarios will be randomly selected. The decisions that you and the other person have made in this scenario determine how much money each of you will be paid. Because you will not know which scenario will be selected until you have made decisions in all of them, you should treat each scenario as if it was the selected one. So, when thinking about each scenario, remember that it could be the selected one and think about it in isolation from the others. Your total earnings for the session will be given by the earnings from the selected scenario, plus a €4 participation payment.

### The scenarios

In each scenario you will face either one or two allocation tasks. Only treatment *PART*: *[You will only discover after you face the first task whether there is going to be a second one.]*

Scenarios with one task In the scenario with one task you and the other person will be asked

to choose between two options, such as the ones shown in Figure 1, by clicking on the button “Choose this option” next to it. The options are the same for you and the other person.

Figure 1: The Scenario with One Task

Options describe allocations of money between you and the other person. One option will always be underlined while the other one will not be underlined. Options will be identified in the same way for both you and the other person. Consider Figure 1 as an example, if in your non-underlined option, you receive €c and the other person receives €d, in the non-underlined option of the other person, you also receive €c and the other person receives €d. The same holds true for the underlined option. So, options that are highlighted in the same way for you and the other person will also report identical allocations between you and the other person.

It might happen that options feature identical allocations.

You receive €a and the other receives €a  
 You receive €a and the other receives €a

We will say that the two options however are different because one is underlined and the other one is not.

While options are uniquely identified for both you and the other person, their relative position (i.e. whether they are at the top or at the bottom) is randomly decided by the computer in every scenario. Some participants will have the underlined option at the top and some at the bottom in some scenarios, and the opposite in some others.

If you and the other person both choose the same option we will say that there is a match.

If you and the other person choose different options, we will say that there is a mismatch.

After you have made your choice, click on the button “OK” to proceed to the next scenario.

### Scenario with two linked tasks

Task 1 in this scenario looks exactly the same as that of the scenario with only one task (Figure 1). However, after you click on the button “OK” in task 1, you and the other person will be presented with a second linked task (Figure 2).

The screenshot shows a web-based interface for a scenario. At the top, a grey header bar contains the text "Scenario" on the left and "1 out 31" on the right. Below this is a light grey instruction bar: "Please select an allocation by clicking on the 'Choose this allocation' button. Click OK to continue." The main area is divided into two sections. The first section, labeled "TASK 1", contains two rows. Each row has a light blue button labeled "Choose this allocation" on the left and a text description on the right. In the first row, the text is "You receive €a and the other receives €b.". In the second row, the text is "You receive €c and the other receives €d.". A light grey bar separates the two tasks, containing the text "The two tasks are linked.". The second section, labeled "TASK 2", also contains two rows with "Choose this allocation" buttons. The first row's text is "You receive €e and the other receives €f.". The second row's text is "You receive €g and the other receives €h.". At the bottom right of the interface is a grey button labeled "OK".

Figure 2: The Scenario with Linked Tasks

In these scenarios, you and the other person will be asked to choose one option from each task.

Let us call twins those options that, in both tasks, are either non-underlined or underlined. In scenarios with linked tasks, you both will have to choose twins. You cannot choose, for example, the underlined option in task 1 and the non-underlined option in task 2. If you do not choose twins you will not be able to proceed to the next scenario. If you were to click on the “OK” button despite this, a pop-up dialog box will appear (see Figure 3).

Notice that the term twins identifies your options in both tasks and is different from the term match. There is a match, in both tasks, only if you and the other person choose the same twins (you both choose the underlined options or you both choose the non-underlined options) and a mismatch, in both tasks, if you and other person choose different twins (you choose the underlined twins and the other chooses the non-underlined twins, or vice-versa).

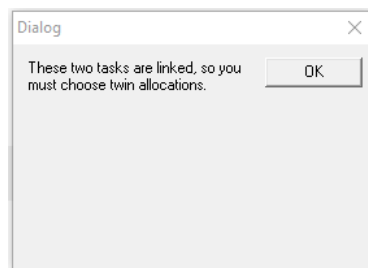


Figure 3: Not Choosing Twin Allocation in the Linked Tasks Scenario

Only treatment *COMP*:

*[Given that decisions in both tasks are linked, you will be allowed to change the option you selected in both tasks before you click on the “OK” button. Once you leave a scenario, you will not be able to go back to it to modify your choices. So, click on the “OK” button only when you are sure those are the options you want to choose.]*

Only treatment *PART*:

*[Given that decisions in both tasks are linked, you will be allowed to change the option you selected in the first task when you are presented with the second one. Once you have chosen your preferred twin options, click on the “OK” button to proceed to the next scenario.]*

Only treatment *PART*:

***[Scenarios with two unlinked tasks]***

*Task 1 in this scenario looks exactly the same as that in the scenario with only one task (Figure 1) and in the scenario with linked tasks (Figure 2). After you click on the “OK” button in task 1, you and the other person will be presented with a second unlinked task (Figure 4).*

*In these scenarios, you and the other person will be asked to choose one option from each task.*

Scenario

1 out 31

Please select an allocation by clicking on the "Choose this allocation" button. Click OK to continue.

TASK 1

Choose this allocation

You receive €a and the other receives €b.

Choose this allocation

You receive €c and the other receives €d.

The two tasks are unlinked.

TASK 2

Choose this allocation

You receive €e and the other receives €f.

Choose this allocation

You receive €g and the other receives €h.

OK

Figure 4: The Scenario with Unlinked Tasks

*The two tasks are unlinked in that your decision in the second task is independent of your decision in the first task. That is, you can choose whichever option you prefer in the second task independently of which option you have chosen in the first task.*

*Given that decisions in both tasks are unlinked, you will NOT be able to change the option you selected in the first task, once you are presented with the second one.*

*Once you have chosen your preferred options, click on the “OK” button to proceed to the next scenario. Once you leave a scenario, you will not be able to go back to it to modify your choices. So, click on the “OK” button only when you are sure that those are the options you want to choose.*

### **What you will know about the scenarios**

*Each scenario will have at least one task and some will have two tasks. You will only know whether the scenario involves two tasks after you have made your decision in the first task. Then, if the scenario has two tasks, you will also be told whether the tasks are linked or unlinked. Given the limited amount of information you have on the type of scenario, you should always choose in*

*the first task as if your decision was final, as you might not be able to change it if the scenario involves only one task or unlinked tasks.]*

### **Earnings**

When you have finished all 31 scenarios, you will be told which of them was selected to determine your earnings. The decisions you and the other person made in that scenario will determine how much each of you will be paid. You will not be able to change your choices at this stage.

The rules that determine your earnings in each task of that scenario are:

o If there is a match you earn the amount(s) reported in the option(s). o If there is a mismatch you earn nothing.

In the scenarios with unlinked tasks, if there is a match in one task and a mismatch in the other task, each of you will only earn the amount reported in the matched allocations and nothing in the other. In the scenarios with linked tasks instead there will be either a match or a mismatch in both tasks, as in those scenarios you can only choose twins. If there is a match each of you will earn the sum of the amounts reported in the chosen allocations in both tasks. If there is a mismatch each of you will earn nothing.