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The Whole and Its Parts: Stoic Ethics in Simple Coordination Games

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Abstract

This paper analyzes the mechanisms by which Stoic ethics can produce coordination. We study how agents satisfying the Stoic discipline of desires (that is, one should wish for nothing that is out of control, including other players' acts) behave in 2-player simultaneous symmetric coordination games. It is shown that the extent to which the Stoic discipline of desires produces coordination depends on the particular way in which this is translated into the language of microeconomics. Under the I1 account of the Stoic discipline of desires (requiring indifference between outcomes that differ only on other players' acts), it is the case either that coordination is achieved or that coordination is valueless. Hence adopting the I1 account suffices to coordinate agents, without any need for a shared idea of the 'Common Good'. On the contrary, the I2 account of the Stoic discipline of desires (requiring indifference between outcomes that are the best given other players' acts) does not always suffice to coordinate agents.

Keywords: Stoicism, games, coordination, rationality, discipline of desires.

JEL classification codes: C70, D01, D60,

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1 Introduction

As North (1981, p. 47) argued, a key function of ethics and morality consists of providing 'the cement of social stability'. Moral and ethical codes make citizens coordinate, in order to ensure the viability of the economic system, and, hence, to ensure the reproduction of the society.[1] According to North's view of history, the study of the economic viability of a society requires an examination of how morality makes citizens coordinate, that is, an examination of how morality guides citizens towards the selection of (shared) social conventions.

From a microeconomic perspective, the analysis of how morality makes citizens coordinate is most challenging. The origin of complexity lies in the various *mechanisms* by which moral codes can produce coordination.[2] One way through which a moral system can make individuals coordinate consists of imposing to them a common conception of the 'social good', a 'common goal' to be pursued. This mechanism is at work in maximalist conceptions of morality, which impose a specific conception of the 'good life'.[3] But coordination can also be achieved by moral codes without imposing a full conception of the 'good life', by partly reshaping persons' desires, through prohibiting or encouraging *some* wants, while letting persons choose their conception of the 'good life' among a large subset of all possible views about the 'good life'. Moreover, in a more minimalist manner, coordination can also be achieved by moral codes without affecting preferences, by merely reshaping how individuals process information.[4]

In the light of these various mechanisms, it is difficult to examine how morality can produce coordination, and, hence, can construct 'the cement of social stability'. The precise answer to that question depends on the moral system under study. Each moral system relies on a particular articulation of various mechanisms that may, under some conditions, produce coordination between individuals. The goal of this paper is to cast light on how moral and ethical codes can, through the articulation of various mechanisms, produce social coordination. How can morality make individuals avoid coordination failures?

In order to examine the relation between morality and coordination, this paper proposes to focus on a particular moral system: Stoicism. One of the four major philosophical schools in Ancient Greece and Rome, Stoicism recommends a conception of the 'good life' defined as *a life in accordance with Nature*.[5] The way in which Stoic philosophers defined a 'life in accordance with Nature' has evolved across centuries (see Brunschwig 2022). Zeno of Citium, the founder of

[1] Moral norms are part of what North calls 'institutions' (North, 1981, p. 201): 'a set of rules, compliance procedures, and moral and ethical behavioural norms designed to constrain the behavior of individuals in the interests of maximizing the wealth or utility of principals'.

[2] For simplicity, we restrict ourselves here to explanations within a static setting.

[3] Aristotle's ethics, which imposes a teleological conception of the good life (a life oriented towards knowledge) is one example of this (see Aristotle's *The Nicomachean Ethics*). See Ogien (2007) on the distinction between maximalist and minimalist conceptions of morality.

[4] One example is Kantian ethics, which was modelled as Kantian optimization (see Laffont 1975, Roemer 2010, 2019). Applications of Kantian optimization include Curry and Roemer (2012), Van Long (2015), Bezin and Ponthiere (2019) and De Donder et al (2025).

[5] On the genesis, the history and the content of Stoicism as a philosophical doctrine, see Goldschmidt (1953), Brun (1980), Hadot (2001) and Brunschwig (2022).

Stoicism in the 4th century BC, regarded the 'good life' as a life in accordance with human nature, that is, a life in line with rationality.[6] However, Zeno's successor at the head of the Stoic school, Cleanthes, defined the 'good life' as a life in accordance with the Universe as a whole. Later on, Cleanthes's successor, Chrysippus, merged these two views and defined the 'good life' as a life in accordance *both* with human nature *and* with the Universe.[7]

Closer to us, philosophers studying Stoicism have provided more precise definitions of a 'life in accordance with Nature'. For instance, the 20th century philosopher Pierre Hadot defined a 'life in accordance with Nature' as a life that satisfies a threefold discipline (Hadot 1978, 2001): (i) a discipline of judgements (that is, to describe things in purely physical terms, which includes a proper delimitation of the self, that is, of the things that are under our own control); (ii) a discipline of desires (that is, to wish for nothing that is not under one's control); (iii) a discipline of acts (that is, for things that are under one's control, one should act for the Common Good).[8] From a Stoic perspective, the combination of disciplines (i)-(iii) is necessary and sufficient to have a virtuous life, because knowing the whole to which one belongs, and desiring and acting accordingly is equivalent to living in accordance with the whole to which one belongs.

The strong emphasis laid by Stoicism on the relation between the whole and its parts makes the issue of coordination particularly central to Stoic philosophy. The whole to which humans belong is the *Polis* or City, and, as a consequence, living a life in accordance with the whole means to live in harmony with other citizens. Such an harmony requires coordination. Coordination between individuals - as parts of the society to which they belong - lies thus at the core of Stoic philosophy. But does Stoic ethics suffice to make individuals coordinate? If yes, what are the mechanisms by which Stoicism produces coordination? These questions motivate the present study, which aims at analyzing the relations between Stoic ethics and the production of coordination.

The goal of this paper is to examine the mechanisms by which Stoic ethics can encourage coordination between individuals. More precisely, we will adopt Hadot's definition of the 'good life' as a life satisfying the Stoic disciplines of judgements, desires and acts, and we will study how the articulation of these three disciplines can allow humans to achieve social coordination. Thus, we will try to identify the conditions under which the Stoic disciplines of judgements, desires and acts can make individuals overcome coordination failures. This analysis is motivated by the will to open the 'black box' of the Stoic system of morality, to decompose it into its basic components, in order to identify their respective roles in the production of coordination.

For that purpose, this paper will study how individuals adopting Stoic morality play coordination games, i.e., games that exhibit, under standard economic

[6] Unlike Epicureanism, Stoicism did not take its name from the name of its founder (Zeno), but from the word *stoa* or portico, the place where Zeno used to make his discourses.

[7] Given that humans - regarded as rational and autonomous beings - are parts of the Universe, a life in line with the Universe must be also in line with human rationality.

[8] Hadot's systematic interpretation of Stoic ethics as a threefold discipline is based on his analysis of the works of Epictetus and Marcus Aurelius (see Hadot, 1978, 2001).

rationality, multiple pure-strategy Nash equilibria (Schelling 1960, Camerer 2003). In those games, there are several self-enforcing conventions, and the existence of multiple pure-strategy Nash equilibria requires agents to coordinate, that is, to adopt the *same* convention. Examples of coordination games include the choice of language: individuals must choose words to be understood, and the dialogue requires them to choose the same communication convention. Other examples of coordination games concern spatial location choices when common location generates positive spillovers, as well as the classification of products (Camerer 2003). This paper aims at studying the conditions under which agents adopting Stoic ethics can coordinate.

	A	B
A	(x, y)	(z, w)
B	(w, z)	(u, v)

Subclass of coordination games	Constraints on the material payoffs matrix
Pure Matching game	$x = y = u = v > z = w$
The Stag-Hunt game	$x = y > u = v = w > z$
The Battle of Sexes game	$x = v > y = u > z = w$
The Hawk-Dove game	$w > x = y > z > u = v$

Table 1: The material payoffs matrices of coordination games.

For the sake of simplicity, this paper will focus on two-player symmetric simultaneous one-shot coordination games, which include, as special cases: the *Pure Matching* game, where players are, under standard economic rationality, indifferent between two pure-strategy Nash equilibria (which involve the same material payoffs for the two players); the *Stag-Hunt* game (Huettel and Lockhead 2000), where players agree on the preferred symmetric pure-strategy Nash equilibrium; the *Battle of Sexes* game, where players have different preferences over symmetric pure-strategy Nash equilibria (Luce and Raiffa 1957); the *Hawk-Dove* game (also known as the Chicken game), where players have different preferences over asymmetric pure-strategy Nash equilibria (Camerer 2003).[9] Table 1 presents the constraints on the material payoffs matrix coinciding with the mentioned subclasses of coordination games.

In order to study the mechanisms through which Stoic ethics can produce coordination, this paper will proceed as follows. To model the behavior of Stoic agents in coordination games, we will assume that players can describe the game in purely physical terms, 'as it is', and, hence, satisfy the Stoic discipline of judgements (i). We will also assume that agents do not use randomization devices, and only consider pure strategies. We will thus focus only on pure-strategy equilibria.[10] Regarding the Stoic discipline of desires (ii), we will adopt the two

[9] This list of coordination games is far from exhaustive. But these classes of coordination games were chosen to illustrate key implications of Stoic ethics for coordination.

[10] The reason for deliberately disregarding mixed strategies is that randomized behaviors are too distant from Stoic morality. From a Stoic perspective, the person who carries out an act must be controlling that act. Thus there is no room for a joint determination of an act by the person and a randomization device.

formalizations proposed by Ponthiere (2024). Each of these formalizations is a translation, into the language of microeconomics, of the Stoic requirement of 'wishing for nothing that is not under one's control', as stated in Epictetus's *Manual*, II. Each microeconomic translation of the Stoic discipline of desires requires *an extension of the symmetric factor of the preference relation beyond its boundaries under standard preferences*: the I1 account of the Stoic discipline of desires requires persons to be indifferent between all outcomes that differ only on things that are not under the person's control (such as other players' acts), while the I2 account of the Stoic discipline of desires requires persons to be indifferent between all outcomes that are the best for them given the things that are not under their control.[11] Finally, regarding the Stoic discipline of acts (iii), we will not impose a particular assumption *a priori*, to study how far Stoic agents can go in reaching coordination *without* having to impose a shared conception of the Common Good. Together, those assumptions will allow us to decompose the mechanisms through which Stoic ethics can produce coordination.

Anticipating our results, the examination of the constraints that the Stoic discipline of desires imposes on the utility payoffs matrix of the game allows us to show that *the Stoic discipline of desires implies some detachment from material payoffs*. It is also shown that the precise form of that detachment depends on the microeconomic translation of the Stoic discipline of desires and on the structure of the coordination game under study. Then, using these restrictions on the utility payoffs matrix, we examine the implications of the Stoic discipline of desires for the outcomes of coordination games. We show that, under the I1 account of the Stoic discipline of desires, there cannot exist a multiplicity of pure-strategy (strict) Nash equilibria: it is either the case that there exists a (strict) dominant strategy equilibrium, or that at least one player is indifferent between all outcomes of the game. However, under the I2 account of the Stoic discipline of desires, one cannot exclude the case of multiple pure-strategy (strict) Nash equilibria. Based on those findings, we show that *the extent to which Stoic ethics allows agents to achieve coordination depends on the formalization of the Stoic discipline of desires*. Under the I1 account of the Stoic discipline of desires, it is either the case that agents achieve coordination, or that coordination is valueless, making any reliance on the Stoic discipline of acts superfluous. Under the I2 account, the Stoic discipline of desires alone does not necessarily allow agents to coordinate. The Stoic discipline of acts is then no longer superfluous, but can be useful in order to avoid coordination failures.

As such, this paper casts light on the conditions under which Stoic ethics allows agents to achieve social coordination. Our findings suggest that the extent to which the Stoic discipline of desires can make agents coordinate depends crucially on the particular microeconomic translation of the Stoic discipline of desires (I1 account or I2 account). Under the I1 account, there is no need to rely on a shared conception of the Common Good, since the Stoic discipline of desires

[11] The I1 and the I2 accounts of the Stoic discipline of desires can have contradictory implications, so that one cannot satisfy both. However, it is important to underline that both the I1 and the I2 accounts of the Stoic discipline of desires can find some support in writings of Stoic philosophers. See Ponthiere (2024).

alone either makes agents coordinate, or makes coordination valueless. However, under the I2 account, the Stoic discipline of desires alone is not, in general, sufficient to produce coordination. Relying, in addition, on a shared conception of the Common Good may here be most useful to achieve coordination. Our results thus cast light on the articulation between the Stoic disciplines of desires and acts that is required to produce coordination within the society.

This paper is related to several branches of the literature. First of all, it is related to the increasingly large literature on moral/ethical preferences in economics, which includes Harsanyi's reexamination of Smith's Impartial Observer (see Harsanyi, 1955, 1976, 1982), Laffont (1975) and Roemer (2010, 2019)'s study of Kant's categorical imperative (Kant 1785), as well as Alger and Weibull (2013, 2016)'s works on the *Homo Moralis*.[12] In particular, this paper is related to Ponthiere (2024), who proposed two microeconomic accounts of the Stoic discipline of desires (the I1 and the I2 accounts). The contribution of the present paper is to highlight, by means of the study of coordination games, that these two accounts are unequal in their capacity to produce coordination. Second, this paper is related to the literature that studied morality in game-theory settings, from the perspective of various moral systems, such as Binmore (1994, 1998, 2005), Curry and Roemer (2012), Roemer (2010, 2019), Van Long (2015), Van Leeuwen and Alger (2024) and Ponthiere (2024, 2025). Whereas that literature focused mainly on the capacity of moral systems to overcome the prisoner's dilemma (i.e., games where a unique Nash equilibrium is Pareto-dominated by a non-equilibrium outcome), the contribution of this paper is to examine the consequences of Stoic morality in coordination games, thus involving, under standard economic rationality, a multiplicity of Nash equilibria. In particular, this paper is related to Binmore's work on morality as a device aimed at promoting coordination through the selection of some equilibrium out of a set of equilibria (Binmore 1994, 1998, 2005). From that perspective, our results provide some support for the I1 account of the Stoic discipline of desires, which suffices to make agents select the 'right' outcome of the game (without any need for a shared conception of the 'Common Good'), whereas the I2 account of the Stoic discipline of desires does not, on its own, suffice to produce coordination.

This paper is organized as follows. Section 2 uses writings from Stoic philosophers - Seneca, Epictetus and Marcus Aurelius - to examine how Stoic ethics defines the right attitude to adopt towards other persons. Then, in order to study the implications of Stoic ethics for the issue of coordination within the society, Section 3 formalizes the Stoic discipline of desires by introducing the I1 account of the Stoic discipline of desires, and examines how agents satisfying the I1 account of the Stoic discipline of desires behave in coordination games. Section 4 carries out a similar task for agents adopting the I2 account of the Stoic discipline of desires. Conclusions are left to Section 5.

[12] Recent works on Alger and Weibull's *Homo Moralis* include Alger and Laslier (2022) and Van Leeuwen and Alger (2024).

2 Stoic ethics and the attitude to others

It is not simple to synthesize what Stoic ethics recommends regarding the attitude that a person should adopt with respect to other persons. The complexity comes from the multiple facets of Stoic ethics. These facets may, at first glance, appear to be in tension with each other. These apparent tensions are related to the distinct ways in which Stoic philosophers - such as Zeno and Cleanthes - defined a 'life in accordance with Nature' (see *supra*). The problem goes as follows. On the one hand, Stoicism recommends a conception of the 'good life' defined as a life in accordance to the whole to which one belongs. In the light of this, one may believe that Stoicism requires that persons are *subordinated* to the society, in the same way as parts are subordinated to the whole.[13] On the other hand, Stoicism recommends also a life in accordance with what a person is - an autonomous and rational being -, and, as such, encourages a *re-centering* of the person towards herself.[14] This re-centering could be interpreted as requiring isolation from others, against intuitions supporting subordination to the society.

The goal of this section is to go beyond these apparent tensions between the different facets of Stoic ethics. As we shall demonstrate, there is no real tension between those facets of Stoic morality.[15] Actually, those facets complement each other and contribute jointly to draw the contours of the right attitude to adopt towards other persons, which is neither subordination, nor isolation.

To study how these facets of Stoic morality are articulated, this section will use writings of some Stoic philosophers - Seneca, Epictetus and Marcus Aurelius - in order to define the virtuous attitude to adopt towards other persons.[16] As we shall see, drawing the contours of the right attitude to adopt towards other persons amounts also to characterize what the 'harmony' or the 'unity' of the person with the society - the whole to which she belongs - consists of.

A first, key feature of Stoic ethics is the goal of *freeing human beings from all sources of alienation.* Being suspended to other persons - that is, allowing these persons to become our own 'masters' - constitutes a major source of alienation from a Stoic perspective, and, as such, is something to be avoided. This point was well stressed by the Stoic philosopher Seneca. In *On the Shortness of Life* (III), Seneca argues that being suspended to other persons - that is, letting other

[13] This view is present in criticisms of Stoicism describing Stoic philosophy - in particular Epictetus's account of Stoicism - as a 'morality for slaves'.

[14] This view is developed in depth in the writings of Seneca and Marcus Aurelius (see *infra*).

[15] By doing so, we will assume that there exists some internal consistency of the Stoic doctrine, in line with Goldschmidt (1953). Note that there is no unanimity on this assumption: alternatively, one could interpret Stoicism - like most Ancient philosophies - not as a consistent system of thought, but, rather, as a practical doctrine recommending daily spiritual exercises. The - widely debated - status of Ancient philosophies is discussed by Hadot (1995).

[16] The reasons why we focus only on those (relatively) late Stoic philosophers are twofold. First, their writings have crossed centuries and have reached us in (quasi) complete forms, unlike what happened for earlier Stoic philosophers (such as Zeno, Cleanthes and Chrysippus), whose writings have only reached us under the (incomplete) form of fragments. Second, whereas early Stoic philosophers like Zeno or Chrysippus were mainly concerned about metaphysics, late Stoic philosophers like Seneca, Epictetus and Marcus Aurelius focused mainly on ethics. This makes their works most relevant for the issue at stake in this paper.

persons become our 'masters' - is an obvious way of wasting one's precious lifetime. According to Seneca, human beings should be less concerned with others, and more concerned with themselves (*On the Shortness of Life* XIX):

> The plight of all preoccupied people is wretched, but most wretched is the plight of those who labor under preoccupations that are not even their own, whose sleep schedule is regulated by somebody else's, who walk at somebody else's pace, and who are under instructions in that freest of all activities-loving and hating. If these people want to know how short their life is, let them reflect on how small a part of it is their very own.

Stoicism aims at freeing humans from a dependency on other persons, which prevents them from really living their own life. For that purpose, Stoic ethics encourages persons to develop their own 'inner citadel', to refer to Marcus Aurelius's expression.[17] This re-centering of the person on herself is a major component of the Stoic conception of the 'good life'. The underlying justification is that a life in a situation of dependency or subordination to others is not a life in agreement with Nature.[18] From a Stoic perspective, humans are, by nature, autonomous, free and rational beings. As a consequence, lives that exhibit dependency on others are not in agreement with these features of human nature, and cannot be regarded as exemplifying the Stoic conception of the 'good life'.

One may be tempted to deduce from this that Stoicism recommends autarky or isolation, and, hence, has little to say on coordination. But such a deduction is erroneous: Stoic ethics does not require autarky. From a Stoic perspective, a 'good life' is a life in accordance with the whole to which one belongs. Each person is a small part of the whole (the City or *Polis*) and thus the pursuit of the 'good life' requires to act in the way that best serves the whole. Best serving the society is generally incompatible with isolation or autarky, but requires some coordination with other persons. This point is best illustrated by Marcus Aurelius's following metaphor (*Thoughts for Myself*, VIII, 34):

> If you have ever beheld an hand, a foot, or an head, cut off from the rest of the body, and lying dead at a distance from it: Such does one make himself, as far as he can, who repines at any event which happens, and tears himself off from the whole; or who does any thing unsociable: You are broke off from the natural unity: Nature formed you for a part of the whole; but you have cut off yourself. Yet this is glorious, that you can re-unite yourself to the whole. The Gods have granted such a power of returning again, and re-uniting with the whole, to no other parts, when they are once cut off. Consider the goodness and bounty with which God hath honoured mankind. He first put it in their power, not to be broken off from this unity; and then put it in their power, even when they are thus broken off, to return, and grow together again naturally, in the condition of parts.

[17] See Marcus Aurelius, XXX.

[18] This key point is also underlined in Epictetus's *Manual*.

According to Marcus Aurelius, a person is a part of the whole, like a foot is a part of the body. A 'good' foot serves the body to which it belongs. Similarly, a person cannot live a 'good life' in isolation: the 'good life' requires that the person best serves the society to which she belongs. Isolation from others cannot be appropriate from that perspective. This would go against the Stoic ideal of 're-unite yourself with the whole'.

In the light of all this, it appears that *Stoic ethics requires persons to best serve the society, but without being subordinated or alienated to any other person.* However, this statement can only be taken as an intermediate step in the definition of the right attitude to other persons. Some key terms remain in need of a definition. What does it mean to 'best serve the society'? What does it mean to 'avoid subordination or alienation to other persons'? In order to draw more precise contours of the virtuous attitude in our relationship with other persons, the rest of this section will rely on Hadot's interpretation of Stoicism as a threefold discipline (Hadot 1978, 2001), and will examine the implications of each of these disciplines for the right attitude to adopt towards other persons.

The Stoic discipline of judgements requires that persons are able to describe the world in purely physical terms, without being influenced by social norms or conventions.[19] One should thus not adopt beliefs as a matter of social convention, that is, on the mere grounds that these beliefs are shared by other persons. On the contrary, each person should make efforts to acquire knowledge. The underlying intuition is that living in harmony with the whole to which one belongs requires acquiring knowledge about the whole.[20] Hence, to the extent that coordination requires knowledge about other persons, the Stoic discipline of judgements legitimates the search for information relevant for coordination.

It should be stressed, however, that this search for information should not be confounded with being suspended to other persons. This point leads us to the Stoic discipline of desires, which requires to wish for nothing that is outside one's control. At this stage, it should be underlined that Stoic ethics relies on a fundamental dogma, which consists of a metaphysical partition of the world into things under control and things out of control. This dogma is presented at the beginning of Epictetus's *Manual* (I):

> Of things some are in our power, and others are not. In our power are opinion, movement towards a thing, desire, aversion, turning from a thing; and in a word, whatever are our acts. Not in our power are the body, property, reputation, offices (magisterial power), and in a word, whatever are not our own acts. And the things in our power are by nature free, not subject to restraint or hindrance; but

[19] This discipline requires, first of all, a precise delimitation of the self, that is, a distinction between what belongs to the self (his thoughts and acts) and what does not belong to the self (others' thoughts and acts). This is in line with the older precept of 'one should know oneself', which dates back to Presocratic thinkers. See Hadot (1995).

[20] Describing the world was a key component of the works of early Stoic philosophers, whose 'physics' followed the long tradition of Presocratic philosophers mainly concerned with the description of the *phusis* or nature (Barnes, 2022). On the Stoic 'physics', which would be classified nowadays as a primary philosophy or metaphysics, see Brun (1980, chapter 3).

> the things not in our power are weak, slavish, subject to restraint, in the power of others.

The Stoic discipline of desires then requires the person to reorient her desires towards things under her control (*Manual* II):

> Take away then aversion from all things which are not in our power, and transfer it to the things contrary to nature which are in our power.

Applying the Stoic discipline of desires to the distinction between one's acts (under one's control) and other persons' acts (which are not under one's control) implies that *a person should not desire anything concerning the acts of other persons*. Indeed, if one has desires towards other persons' acts, one is condemned to be like a slave, enchained to others. Other persons' acts are out of our control. Hence, desiring anything concerning other persons' acts would make us subordinated to others. Alienation is not desirable from a Stoic perspective. Thus the Stoic discipline of desires states that avoiding any desire towards other persons' acts is necessary to prevent the subordination to other persons.

While the Stoic disciplines of judgements and desires point to some necessary requirements for adopting the right attitude towards other persons, they do not exhaust all such requirements. Actually, our attitude towards others should also respect the Stoic discipline of acts. According to the Stoic discipline of acts, each person should act in line with the values of the City, that is, in line with the Common Good (the *summum bonum*). As we stressed above, the underlying intuition is that a good life requires to live in accordance with the whole to which one belongs, that is, with the society. Back to Marcus Aurelius's metaphor of the parts of a body, all citizens should act in harmony in the society, exactly as parts of the body work in harmony in the healthy body.

The Stoic discipline of acts is well summarized in the following quote, taken from Marcus Aurelius's *Thought to Myself* (X, 7):

> Whether all be atoms, or there be [presiding] natures, let this be laid down as indisputable; that I am a part of the whole; and the whole must be conducted by its own nature, be that what it will: and that I am in some manner socially connected with the parts which are of the same kind with myself. For while I remember this, I shall, as I am a part, be dissatisfied with nothing appointed me by the whole. For nothing advantageous to the whole is hurtful to the part. For the whole has nothing in it but what is advantageous to itself; that being common to all natures; and the nature of the whole has this further, that it can't be forced by any external cause, to produce any thing hurtful to itself. By remembering, then, I am a part of such a whole, I shall be well-pleased with every thing which comes from it. And as far as I am in some manner one of the same family with the parts of the same kind with me, I will be guilty of nothing unsocial; nay, I will rather aim at the good of my kind; turn the whole bent of

> my will to the public advantage, and withdraw it from the contrary. When I accomplish these things in this manner, my life must needs run smooth and clear: Just so, as you would judge a citizen in a happy flow of life, who was going on in a course of action profitable for his fellow citizens, and gladly embracing whatever is appointed him by the city.

The Stoic discipline of acts involves accepting everything that comes from the whole, because 'nothing advantageous to the whole is hurtfull to the part'. But the Stoic discipline of acts goes beyond that acceptance. It requires serving the whole to which one belongs, that is, the *Polis* or City. Note that this requirement presupposes some shared conception of the 'Common Good'. This shared conception of the social goal to be pursued consists of the values of the City, i.e., the things and behaviors that the City would like to encourage. The values of the City determine how each citizen should best serve the society. From that perspective, not all acts carried out by a person are equally good: these acts are good only to the extent that they best serve the values of the City. Stoicism thus involves a reduction of 'Goodness' to 'Moral Goodness'.[21]

Taken together, the Stoic disciplines of judgements, of desires and of acts allow us to draw the contours of the right attitude to adopt towards other persons. From a Stoic perspective, having a 'good life' requires being in 'harmony' or in 'unity' with the whole to which one belongs. This 'harmony' or 'unity' with the whole can be achieved by serving other persons, but without desiring anything about other persons' acts (because such a desire would cause alienation or subordination to other persons). *The Stoic conception of the 'good life' - defined as a life in harmony with the whole to which the person belongs - requires the person to best serve the society (thus, other persons) through her own acts, but while remaining, at the same time, an independent, autonomous and rational part of that whole, which excludes being suspended to other persons' acts.*

If one interprets 'being in harmony with the other members of the society' as a definition of 'coordination', one can interpret Stoic ethics as nothing less than *a requirement of coordination of all members of the society.* But this requirement does not tell us *how* the coordination or harmony can be achieved. Through which mechanisms can Stoic ethics achieve coordination? Does the mere conjunction of the Stoic disciplines of judgements and desires suffice to produce coordination? Or, alternatively, are additional assumptions needed in order to achieve coordination? In particular, does the production of coordination require a shared idea of the 'Common Good' (as supposed in the Stoic discipline of acts)? To answer these questions, the next sections will examine the implications of the Stoic disciplines of judgements and desires for the outcome of 2-player simultaneous coordination games.

[21] On the Stoic reduction of the 'Good' to the 'Moral Good', see Hadot (2001).

3 Stoicism and coordination: the I1 account

The goal of this section is to examine the implications of Stoic ethics for the production of coordination between agents. For that purpose, we will analyze how Stoic ethics affects the outcomes of 2-player simultaneous one-shot coordination games, as summarized in Table 1 (Section 1). We will use our analyzes of those coordination games in order to decompose the mechanisms that are, within Stoic ethics, at work behind the production of social coordination.

To examine the implications of Stoic ethics in coordination games, we will assume that individuals can collect all relevant pieces of information concerning the games (in line with the Stoic discipline of judgements).[22] Moreover, we will suppose that individuals adopt the Stoic discipline of desires, that is, they do not desire anything regarding things that are not under their own control. However, for the sake of parsimony, this section will not assume that agents satisfy the Stoic discipline of acts. The reason is that assuming this would amount to suppose a shared conception of the 'Common Good', a strong assumption. Instead, this section will not assume such a shared view of the 'Common Good', but will rather study the conditions of emergence of coordination between agents satisfying only the Stoic disciplines of judgements and desires.[23]

The Stoic discipline of desires has strong implications in game-theory contexts. A person controls her own acts, but cannot control the acts of other persons. Given that other persons' acts belong to other persons - and not to the self -, the Stoic discipline of desires applies to other players' acts: *a person should not desire anything regarding the acts of other persons.* In other words, the Stoic requirement of 'indifference to indifferent things' requires that the person is indifferent to other persons' acts, and cares only about her own acts.

The study of the implications of Stoic ethics in coordination games requires first to formalize the Stoic discipline of desires, that is, to 'translate' it into the language of microeconomics. This requires to model what it means 'to wish for nothing that is outside one's control' (including other players' acts).

As argued by Ponthiere (2024), a first way to formalize the Stoic discipline of desires consists of requiring that the person is indifferent between all outcomes of the game that differ only on what is not under the player's control, that is, that differ only regarding other players' acts. Denoting by $u_i(a, a_{-1})$ the utility payoff for player i when he plays $a \in \{A, B\}$ and the other player plays $a_{-1} \in \{A, B\}$, the Stoic discipline of desires can be formalized as follows.

Definition 1 (I1 account of Stoic discipline of desires) *A player i satisfies the I1 account of the Stoic discipline of desires if and only if he is indifferent between all outcomes of the game that differ only on the other player's acts:*

$$u_i(A, A) = u_i(A, B) \quad \text{and} \quad u_i(B, A) = u_i(B, B)$$

[22] In other words, the structure of the game (players, feasible acts, possible outcomes and material payoffs) are all common knowledge to all players.

[23] At the methodological level, this assumption of adherence to some - but not all - disciplines of Stoicism will allow us to decompose the mechanisms through which Stoic ethics can produce coordination (see *infra*).

The intuition behind the I1 account of the Stoic discipline of desires goes as follows. A player controls his acts, but cannot control the acts of the other player. Hence, if things outside her control make no difference for a person, then that person should be strictly *indifferent* between all outcomes of the game that differ only on those things outside control (i.e., the other player's act).[24] This implies that each player should be indifferent between all outcomes of the game that differ only on the other player's act.

Let us now examine the implications of adopting the I1 account of the Stoic discipline of desires for the assessment of the outcomes of a game. As this is illustrated on Table 2, the I1 account of the Stoic discipline of desires imposes a restriction on the matrix of utility payoffs assigned to the outcomes of the game: the *same act* should yield the *same utility payoff* for a given player, no matter what the act of the other player is.[25] Hence, under the I1 account of the Stoic discipline of desires, the utility payoff enjoyed by each player can only take as many values as there are distinct acts (thus 2 levels in a game with 2 acts).

	A	B
A	$(u_1(A,A) = \bar{u}, u_2(A,A) = \check{u})$	$(u_1(A,B) = \bar{u}, u_2(B,A) = \tilde{u})$
B	$(u_1(B,A) = \hat{u}, u_2(A,B) = \check{u})$	$(u_1(B,B) = \hat{u}, u_2(A,A) = \tilde{u})$

Table 2. Utility payoffs matrix under the I1 account.

The restrictions on the utility payoffs matrix shown in Table 2 are general, and hold for any 2-player coordination game, whatever the precise class of games is, and, thus, whatever the material payoffs matrix of the game is. Using these restrictions on the utility payoffs matrix, we can then study the various possible outcomes of the coordination game prevailing under the I1 account of the Stoic discipline of desires. Proposition 1 summarizes our results.

Proposition 1 *The I1 account of the Stoic discipline of desires excludes the existence of a multiplicity of pure-strategy strict Nash equilibria. It is the case either that there exists a strict dominant strategy equilibrium in the game, or that there exists no pure-strategy strict Nash equilibrium (because, in that alternative case, at least one player is globally indifferent between all outcomes of the game).*

Proof. See the Appendix. ■

According to Proposition 1, players who adopt the I1 account of the Stoic discipline of desires cannot face a game exhibiting several (pure-strategy) strict Nash equilibria. Stoic morality - under the form of the I1 account of the Stoic discipline of desires - excludes the multiplicity of (pure-strategy) strict Nash equilibria. Note that this result is obtained from the general restrictions imposed

[24] As underlined by Ponthiere (2024), the I1 account of the Stoic discipline of desires can be defended as a literal translation, in microeconomic terms, of this requirement stated by Epictetus (*Manual*, XXXII):

> For if it is any of the things which are not in our power, it is absolutely necessary that it must be neither good nor bad.

[25] It is assumed that utility payoffs $\bar{u}$, $\hat{u}$, $\check{u}$ and $\tilde{u}$ are real numbers.

by the I1 account on the structure of utility payoffs matrix, and, as such, prevails for all material payoffs matrices, and, thus, whether one considers, for instance, a Pure Matching game, a Stag-Hunt game or a Hawk-Dove game.

The result stated in Proposition 1 is somewhat surprising, because it is at odds with what a coordination game is about. By construction, coordination games are games that exhibit - at least - two (pure-strategy) strict Nash equilibria, among which players must find a way to coordinate, possibly by appealing to a focal point.[26] But Proposition 1 states that, if players adopt the I1 account of the Stoic discipline of desires, there cannot be a multiplicity of (pure-strategy) strict Nash equilibria, unlike what occurs under standard economic rationality. *Under the I1 account of the Stoic discipline of desires, the problem of selection between several (pure-strategy) strict Nash equilibria cannot occur.*

The intuition behind that result goes as follows. From a Stoic perspective, a person should not be suspended to other persons' acts. Hence, a person should care only about her *own acts*, rather than about *outcomes*, which are the joint product of her acts with other players' acts. To avoid being enchained to others, the I1 account of the Stoic discipline of desires requires that the person is, *ceteris paribus*, indifferent to what the other player chooses to do - something not under her control -. Under this constraint, it is impossible to have several (pure-strategy) strict Nash equilibria. Either there exists a strict dominant strategy for each player - leading to a strict dominant strategy equilibrium -, or at least one player has no dominant strategy, and thus must, under the I1 account, be necessarily indifferent between all outcomes of the game.

This re-centering of the person on her own acts - no matter what the consequences are - involves some *detachment from the material payoffs* resulting from the acts chosen by all players.[27] This detachment from material payoffs comes from the fact that the I1 account requires that a player is indifferent between all outcomes where he plays the same act, no matter what other players do. Interestingly, the detachment from material payoffs prevailing under the I1 account of the Stoic discipline of desires - as well as its concrete implications - vary with the particular coordination game considered. The intuition behind that finding is that the result stated in Proposition 1 is based on general restrictions imposed by the I1 account of the Stoic discipline of desires on the utility payoffs matrix, *independently from the structure of the material payoffs matrix.*

To illustrate this key point, consider first the following Pure Matching game (where $x = y = u = v = 1 > z = w = 0$):[28]

	A	B
A	(1, 1)	(0, 0)
B	(0, 0)	(1, 1)

Table 3: The Pure Matching game: material payoffs matrix.

[26] What it means for a strategy to be focal has been the object of a voluminous literature in the recent decades. See Bacharach and Bernasconi (1997) and Camerer (2003).

[27] Utility payoffs are thus no longer correlated with material payoffs, unlike what is the case under standard economic rationality.

[28] This example is taken from Camerer (2003), p. 343.

Under standard economic rationality, this game exhibits two (pure-strategy) strict Nash equilibria (A, A) and (B, B), between which each player is indifferent.[29] But this result is not true once players adopt the I1 account of the Stoic discipline of desires. Indeed, the I1 account requires each player to be indifferent between (A, A) and (A, B), and between (B, B) and (B, A). Hence, if a player is indifferent between (A, A) and (B, B), it follows from the I1 account that this player must be indifferent between *all* outcomes of the game. This exemplifies an extreme detachment from material payoffs. But this needs not to be the case. Alternatively, a player satisfying the I1 account may not be indifferent between (A, A) and (B, B). Then, this player will have a strict dominant strategy. But here again, the I1 account of the Stoic discipline of desires involves a detachment from material payoffs: the material gains from 'matching' with the other player become, under the I1 account, irrelevant for welfare. *Under the I1 account of the Stoic discipline of desires, it is the act carried out that matters per se, independently from the fact of 'matching' (or not) with the other player.*

Let us now consider the Stag-Hunt game, illustrated on Table 4 (where $x = 2, u = 1$ and $z = 0$).[30]

	Stag	Rabbit
Stag	(2, 2)	(0, 1)
Rabbit	(1, 0)	(1, 1)

Table 4: The Stag-Hunt game: material payoffs matrix.

Under standard economic rationality, the game of Table 4 exhibits two (pure-strategy) strict Nash equilibria. Indeed, if one assumes that the utility of each player is strictly increasing with material payoffs, we see that the best reply of a player when the other player hunts the stag is to hunt the stag too (in order to enjoy a material payoff of $2 > 1$), and, also, that the best reply of a player when the other player hunts the rabbit is to hunt the rabbit too (in order to enjoy a material payoff of $1 > 0$). Thus (Stag, Stag) and (Rabbit, Rabbit) are two (pure-strategy) strict Nash equilibria. However, this rationale does not hold under the I1 account of the Stoic discipline of desires. From a Stoic perspective, only the acts carried out by the person matter for her, independently from what other players choose to do. Thus hunting the stag brings the same utility payoff for a player no matter whether or not the other player hunts also the stag, or hunts the rabbit, even though, from a material perspective, material payoffs are higher for the player when both players hunt the stag. Hence, under the I1 account, each player of the Stag-Hunt game is detached from material payoffs, in the sense that only the person's act is valued by the person, no matter what its material consequences are. *Under the I1 account of the Stoic discipline of desires, the only thing that matters for agents playing the Stag-Hunt game is to*

[29] It is assumed here that utility payoffs are, under standard economic rationality, strictly increasing in material payoffs. Of course this assumption does not necessarily hold under the Stoic discipline of desires.

[30] This example is taken from Camerer (2003), p. 376.

be a stag-hunter or a rabbit-hunter, no matter what the outcome of the hunting activity is.

Consider now the Battle of the Sexes game (where $x = v = 2 > y = u = 1 > z = w = -1$):[31]

	Prize Fight	Ballet
Prize Fight	(2, 1)	(-1, -1)
Ballet	(-1, -1)	(1, 2)

Table 5: The Battle of the Sexes game: material payoffs matrix.

Under standard rationality, there exist two (pure-strategy) strict Nash equilibria (Prize Fight, Prize Fight) and (Ballet, Ballet). Player 1 prefers the first outcome over the second one, whereas Player 2 prefers the second outcome over the first one. But this multiplicity of strict Nash equilibria cannot occur under the I1 account of the Stoic discipline of desires. The I1 account requires the person not to be suspended to the other's act, in the sense that each player should be indifferent between all outcomes of the game where he plays the same act. Thus Player 1 is indifferent between (Prize Fight, Prize Fight) and (Prize Fight, Ballet), and between (Ballet, Prize Fight) and (Ballet, Ballet), whereas Player 2 is indifferent between (Prize Fight, Ballet) and (Ballet, Ballet), and between (Prize Fight, Prize Fight) and (Ballet, Prize Fight). The I1 account requires each player to either prefer Prize Fight *unconditionally*, or to prefer Ballet *unconditionally*, or to exhibit global indifference. Thus each couple member is not suspended to the spouse's act. *Under the I1 account of the Stoic discipline of desires, each spouse does not care about whether or not his/her spouse attends the same event as the one that he/she attends. The Stoic detachment makes the 'battle' of the sexes vanish.*

Finally, consider the Hawk-Dove game (where $w = 4 > x = y = 2 > z = 1 > u = v = 0$):

	Modest	Grasping
Modest	(2, 2)	(1, 4)
Grasping	(4, 1)	(0, 0)

Table 6: The Hawk-Dove game: material payoffs matrix.

Under standard rationality, the game exhibits two (pure-strategy) strict Nash equilibria (Grasping, Modest) and (Modest, Grasping). However, under the I1 account of the Stoic discipline of desires, each player must be indifferent between (Modest, Modest) and (Modest, Grasping), and, also, between (Grasping, Modest) and (Grasping, Grasping). These indifference requirements imply that each player regards the outcome where he plays Grasping whereas the other player plays Modest as exactly as bad as the (catastrophic) outcome (Grasping, Grasping). *In a Hawk-Dove game, players satisfying the I1 account of the Stoic discipline of desires are indifferent between the outcome (Grasping, Modest) where they dominate the other player and the outcome (Grasping, Grasping)*

[31] This example is taken from Luce and Raiffa (1959), p. 90.

where players neutralize each other. Again, this illustrates the kind of detachment from material payoffs required by the I1 account of the Stoic discipline of desires.

Although the form of the detachment from material payoffs varies across games, the results stated in Proposition 1 are general, and apply to all 2x2 simultaneous coordination games.[32] The intuition is that Stoic morality requires persons not to be suspended to other persons' acts. When modelled as the I1 account of the Stoic discipline of desires, this requirement leads to a detachment from material payoffs associated to the outcomes of the game: only the acts carried out by the person matter for her. Hence, the utility payoff matrix excludes a multiplicity of strict (pure-strategy) Nash equilibria.

What are the implications of Proposition 1 for the possibility of Stoic agents to coordinate? Does the re-centering of each agent on his own acts contribute to prevent coordination, or, on the contrary, to allow for coordination? Our results are stated in Corollary 1.

Corollary 1 *Under the I1 account of the Stoic discipline of desires, it is either the case that players can coordinate on the best outcome of the game (in terms of utility payoffs), or that coordination is valueless to them.*

Proof. See the Appendix. ■

Corollary 1 states that, when players adopt the I1 account of the Stoic discipline of desires, it is either the case that agents can coordinate on the best social outcome (i.e., the one that yields the highest utility payoffs for each player), or that they cannot, but in the latter case this lack of coordination is benign, since it causes no welfare loss. Thus the I1 account of the Stoic discipline of desires either allows agents to coordinate, or makes coordination unnecessary.

The intuition behind that result goes as follows. Coordination issues arise when there exists a multiplicity of (pure-strategy) strict Nash equilibria. However, based on Proposition 1, the I1 account of the Stoic discipline of desires rules out the possibility of multiple (pure-strategy) strict Nash equilibria: it is the case either that there exists a strict dominant strategy equilibrium, or that there exists no (pure-strategy) strict Nash equilibrium. In the former case, agents can coordinate on a particular outcome of the game (i.e., the dominant strategy equilibrium), because each agent plays his (strict) best strategy, which leads to the (strict) dominant strategy equilibrium. In the latter case, agents cannot coordinate on an outcome, but this is not problematic, since agents are indifferent between all outcomes that can emerge out of the game.

Corollary 1 states that, *if agents adopt the I1 account of the Stoic discipline of desires, the detachment from material payoffs is such that either coordination on the best outcome of the game can be achieved, or coordination is valueless.* Hence, there is no need here to rely on the idea of a focal point (Schelling 1960, Camerer 2003) to produce the coordination of agents on the best outcome of

[32] Thus agents satisfying the I1 account of the Stoic discipline of desires cannot face a multiplicity of (pure-strategy) strict Nash equilibria in Pure Matching games, in Stag-Hunt games, in Battle of the Sexes games, and in Hawk-Dove games.

the game. The reason is that the I1 account of the Stoic discipline of desires, by making the multiplicity of (pure-strategy) strict Nash equilibria impossible, makes such a focal point useless: the mere detachment from material payoffs does the job of coordinating agents (or makes coordination valueless).

To illustrate Corollary 1, let us turn back to the Stag-Hunt game.

	Stag	Rabbit
Stag	(2, 2)	(0, 1)
Rabbit	(1, 0)	(1, 1)

Table 4: The Stag-Hunt game: material payoffs matrix.

Based on Proposition 1, we know that, when players adopt the I1 account of the Stoic discipline of desires, only two cases can occur: either there exists a strict dominant strategy equilibrium, or there exists no (pure-strategy) strict Nash equilibrium. Suppose, to illustrate the first case, that (Stag, Stag) is the strict dominant strategy equilibrium. It is then the case that, under the I1 account of the Stoic discipline of desires, the (Stag, Stag) outcome, which is achieved by agents, brings the highest utility payoffs for all players.[33] Consider now the second case, where there exists no (pure-strategy) strict Nash equilibrium. In that case, we know from Proposition 1 that at least one Stoic player is indifferent between all outcomes of the game. Hence, not achieving coordination on a given outcome of the game is benign, because the player who is indifferent between all outcomes cannot suffer from not achieving coordination, whereas the player who is not indifferent between all outcomes can, by his own act, make the outcome of the game in line with his strict preferences. Thus, in that second case, no player suffers from the lack of coordination.

This general result - either the two players can coordinate on the best outcome, or coordination is valueless (for at least one player) - also prevails in Pure Matching games, in Battle of the Sexes games, and in Hawk-Dove games. The reason is that the I1 account of the Stoic discipline of desires imposes, in all those games, exactly the same constraints on the utility payoffs matrix, thus yielding the same corollary regarding the possibility to coordinate.

In sum, *the I1 account of the Stoic discipline of desires can act as a powerful coordination device*: the constraints imposed by the I1 account on the utility payoffs matrix are such that it is either the case that the game admits a strict dominant strategy equilibrium on which agents can, by construction, coordinate, or, alternatively, that the game admits no (pure-strategy) strict Nash equilibrium, in which case the lack of coordination yields no welfare loss.

As such, this section casts light on the mechanisms through which Stoic morality can achieve coordination between citizens, and, hence, contributes to construct the 'cement of social stability'. When formalized as the I1 account, the Stoic discipline of desires suffices to make agents coordinate on the same (desirable) outcome of the game. There is thus no role to be played here by a shared view of the 'Common Good' (common goals). The discipline of acts is

[33] Otherwise, (Stag, Stag) would not be the strict dominant strategy equilibrium under the I1 account of the Stoic discipline of desires.

superfluous here, because the I1 account of the Stoic discipline of desires *alone* either suffices to produce coordination, or makes coordination valueless.[34]

4 Stoicism and coordination: the I2 account

There is no unique manner to formalize the Stoic idea of wishing for nothing that is outside one's control. While the I1 account is one possible microeconomic translation of the Stoic requirement of 'indifference to indifferent things', an alternative formalization consists of the I2 account. As defined by Ponthiere (2024), the I2 account of the Stoic discipline of desires requires that the person is *indifferent* between all outcomes that are the best given the prevailing circumstances (i.e., things outside one's control). The underlying idea is that, from a Stoic perspective, circumstances (such as the other players' acts) do not matter, as long as the person can 'make the best' out of those circumstances. This alternative interpretation of the Stoic discipline of desires can find support in various Stoic writings, such as Epictetus's handles metaphor (*Manual*, XLIII).[35] Another source for the I2 account is Marcus Aurelius's bright fire metaphor (*Thoughts for Myself*, IV).[36]

In comparison with the I1 account of the Stoic discipline of desires, the I2 account captures another facet of the Stoic conception of the 'good life', defined as 'a life in agreement with Nature'. Here the agreement with Nature takes the form of a perfect reaction to Nature, that is, a perfect harmony with elements that are external to the self. Being in perfect harmony with circumstances is here the only thing that matters. Once harmony with circumstances is achieved, circumstances themselves become irrelevant, and make no difference any more.

In a game-theory context, where other players' acts are outside control, the I2 account of the Stoic discipline of desires can be formulated as follows.

[34] This does not imply that the Stoic discipline of acts is superfluous *in general*, but only that, for the coordination problems studied in this paper, the I1 account of the Stoic discipline of desires suffices to achieve coordination.

[35] Epictetus's handles metaphor goes as follows (*Manual*, XLIII):

> Everything has two handles, the one by which it may be borne, the other by which it may not. If your brother acts unjustly, do not lay hold of the act by that handle wherein he acts unjustly, for this is the handle which cannot be borne; but lay hold of the other, that he is your brother, that he was nurtured with you, and you will lay hold of the thing by that handle by which it can be borne.

[36] Marcus Aurelius's bright fire metaphor goes as follows (*Thoughts to Myself*, IV, 1):

> When the governing part is in its natural state, it can easily change and adapt itself to whatever occurs as the matter of its exercise. It is not fondly set upon any one sort of action. It goes about what seems preferable, with a proper reservation.1 And if any thing contrary be cast in, makes this also the matter of its proper exercise. As a fire, when it masters the things which fall on it, tho' they would have extinguished a small lamp: the bright fire quickly assimilates to itself and consumes what is thrown into it, and even thence increases its own strength.

Definition 2 (I2 account of Stoic discipline of desires) *A player i satisfies the I2 account of the Stoic discipline of desires if and only if he is indifferent between all outcomes of the game that involve the best reply to the other player's acts. Denoting the best reply to player $j \neq i$ playing $a \in \{A, B\}$ as $R(a)$, we have:*

$$u_i\left(R(A), A\right) = u_i\left(R(B), B\right)$$

In order to understand the constraints that the I2 account of the Stoic discipline of desires imposes on agents' behaviors, it is useful to examine its implications for the form of the utility payoffs matrix. For that purpose, Table 7 reproduces the utility payoffs matrix in a 2x2 game.[37]

	A	B
A	$(u_1(A, A) = \bar{u}, u_2(A, A) = \check{u})$	$(u_1(A, B) = \grave{u}, u_2(B, A) = \tilde{u})$
B	$(u_1(B, A) = \hat{u}, u_2(A, B) = \acute{u})$	$(u_1(B, B) = \hat{u}, u_2(A, A) = \grave{u})$

Table 7. Utility payoffs matrix under the I2 account.

Compared to the I1 account of the Stoic discipline of desires, the I2 account imposes fewer restrictions on utility payoffs. Indeed, the I1 account imposes that the utility payoffs for a player depend only on his own act, no matter what the other agent plays, which leads, in a 2x2 game, to a two-level utility function for each player. However, under the I2 account, there is no such a restriction. Actually, the only restriction is the requirement of equality of utility payoffs associated to each player's best reply to the other player's act. For instance, if Player 1's best reply to Player 2 choosing act A is to play A, and if Player 1's best reply to Player 2 choosing act B is to play B, then the I2 account of the Stoic discipline of desires requires the equality $\bar{u} = \hat{u}$. Thus the I2 account imposes relatively mild constraints on the utility payoffs matrix.

As a consequence of these mild constraints, the I2 account of the Stoic discipline of desires has fewer implications regarding the possible outcomes of the game, unlike the I1 account (see Proposition 1).

Proposition 2 *The I2 account of the Stoic discipline of desires does not exclude the possibility of two (pure-strategy) strict Nash equilibria along the diagonal or off the diagonal, but excludes the possibility of two (pure-strategy) strict Nash equilibria along a column or a row of the game. It is the case either that there exists a strict dominant strategy equilibrium, or that there exist two (pure-strategy) strict Nash equilibria along the diagonal or off the diagonal, or that there exists one (pure-strategy) strict Nash equilibrium, or that there exists no (pure-strategy) strict Nash equilibrium.*

Proof. See the Appendix. ■

Proposition 2 states that the I2 account of the Stoic discipline of desires has fewer implications regarding the outcome of 2x2 coordination games in comparison with the I1 account. Indeed, whereas the I1 account excluded the

[37] It is assumed that utility payoffs $\bar{u}$, $\hat{u}$, $\check{u}$, $\tilde{u}$, $\acute{u}$, $\hat{u}$, $\grave{u}$ and $\hat{u}$ are real numbers.

existence of multiple (pure-strategy) strict Nash equilibria, the multiplicity of (pure-strategy) strict Nash equilibria is possible under the I2 account of the Stoic discipline of desires: there can exist two (pure-strategy) strict Nash equilibria along the diagonal or off the diagonal of the game.

The intuition behind that result lies in the fact that the I2 account of the Stoic discipline of desires imposes fewer restrictions on the utility payoffs matrix in comparison to the I1 account. The only restriction is that the person should be indifferent between all outcomes of the game where she plays her best reply to the other player's act. This requires, among other things, that if there are two (pure-strategy) strict Nash equilibria, each player should be indifferent between these two outcomes of the game, because these are, by definition, outcomes where each player does the best he can, in line with Epictetus's handles metaphor. This indifference involves some form of detachment of the player from material payoffs, because the two (pure-strategy) strict Nash equilibria may not be, for the player, equivalent in terms of material payoffs.

Let us now examine the detachment from material payoffs implied by the I2 account of the Stoic discipline of desires. For that purpose, it is useful to reconsider the four subclasses of coordination games studied previously.

Consider first the Pure Matching game of Table 3:

	A	B
A	(1, 1)	(0, 0)
B	(0, 0)	(1, 1)

Table 3: The Pure Matching game: material payoffs matrix.

The only requirement of the I2 account of the Stoic discipline of desires is that each player is indifferent between all outcomes of the game where they play the best reply to the other player's act. Thus, if (A, A) and (B, B) are two strict Nash equilibria, the I2 account of the Stoic discipline of desires only requires that each player is indifferent between outcomes (A, A) and (B, B). In the case of the Pure Matching game of Table 3, this is a mild requirement, because the two (pure-strategy) strict Nash equilibria are strictly equivalent in terms of material payoffs. *In a Pure Matching game with Nash equilibria along the diagonal, the only thing that matters for Stoic agents under the I2 account of the Stoic discipline of desires is to 'match' with the other player, unlike what prevails under the I1 account (where the 'matching' is irrelevant).*

Although the I2 account of the Stoic discipline of desires imposes a somewhat minimalist detachment from material payoffs in the Pure Matching game, the same is not true in the Stag-Hunt game.

	Stag	Rabbit
Stag	(2, 2)	(0, 1)
Rabbit	(1, 0)	(1, 1)

Table 4: The Stag-Hunt game: material payoffs matrix.

Suppose that (Stag, Stag) and (Rabbit, Rabbit) are two strict Nash equilibria. Then, the I2 account of the Stoic discipline of desires requires that each

player is strictly indifferent between these two outcomes. This requires a strong detachment from material payoffs, because each player is, in material terms, better off in the (Stag, Stag) outcome than in the (Rabbit, Rabbit) outcome. *In Stag-Hunt games with Nash equilibria along the diagonal, what matters for agents satisfying the I2 account of the Stoic discipline of desires is that agents share the same hunting activity, no matter which hunting activity is shared.* This detachment from material payoffs differs from the one prevailing under the I1 account, where being a stag-hunter or a rabbit-hunter is the only thing that matters for each agent, no matter the other agent's hunting activity (see *supra*).

Similarly, the I2 account of the Stoic discipline of desires imposes also a strong detachment from material payoffs in the Battle of the Sexes game.

	Prize Fight	Ballet
Prize Fight	(2, 1)	(-1, -1)
Ballet	(-1, -1)	(1, 2)

Table 5: The Battle of the Sexes game: material payoffs matrix.

Suppose that (Prize Fight, Prize Fight) and (Ballet, Ballet) are two strict Nash equilibria. The I2 account of the Stoic discipline of desires requires here that Player 1 is indifferent between (Prize Fight, Prize Fight) and (Ballet, Ballet). This requires a strong detachment from material payoffs, since Player 1 has higher material payoffs in the outcome (Prize Fight, Prize Fight). Similarly, the I2 account requires also that Player 2 is indifferent between (Prize Fight, Prize Fight) and (Ballet, Ballet), which requires a strong detachment from material payoffs, since Player 2 has higher material payoffs in (Ballet, Ballet). Thus the I2 account of the Stoic discipline of desires imposes here a strong form of detachment from material payoffs. *In a Battle of Sexes game with Nash equilibria along the diagonal, the only thing that matters for spouses satisfying the I2 account of the Stoic discipline of desires is sharing the activity with the spouse, no matter whether or not the shared activity is the preferred activity.* This detachment from material payoffs is to be contrasted with the one induced by the I1 account of the Stoic discipline of desires, under which sharing an activity (with the spouse) is irrelevant for welfare (see *supra*).

Finally, consider the following Hawk-Dove game.

	Modest	Grasping
Modest	(2, 2)	(1, 4)
Grasping	(4, 1)	(0, 0)

Table 6: The Hawk-Dove game: material payoffs matrix.

Suppose that (Grasping, Modest) and (Modest, Grasping) are the two strict Nash equilibria. Then the I2 account of the Stoic discipline of desires requires that each player is strictly indifferent between these outcomes. This implies a detachment from material payoffs, because Player 1 is better off, in material terms, in (Grasping, Modest) than in (Modest, Grasping), whereas the opposite holds for Player 2. *In a Hawk-Dove with Nash equilibria off the diagonal, the*

only thing that matters for players satisfying the I2 account is to achieve an asymmetry of roles, no matter who plays Modest and who plays Grasping. This detachment from material payoffs differs from its form under the I1 account, where each player is indifferent between all outcomes where he chooses the same act, no matter what the other agent plays (see *supra*).

All this illustrates that the I2 account of the Stoic discipline of desires imposes a significant detachment from material payoffs, even though this is not the case in Pure Matching games. Moreover, our few examples illustrate also that the detachment from material payoffs induced by the I2 account differs from the detachment induced by the I1 account. In a nutshell, under the I1 account of the Stoic discipline of desires, the detachment from material payoffs is such that the only thing that matters for the agent is the chosen act *per se*, no matter what its material consequences are. Under the I2 account of the Stoic discipline of desires, the detachment from material payoffs takes another form: the only thing that matters for the agent is to play the best reply to what the other agent does, no matter what the material consequences are.

But what are the implications of the I2 account of the Stoic discipline of desires for the issue of coordination? Can the I2 account guide players towards coordination on the best outcome of the game?

Unfortunately, the answer is mixed, as stated in Corollary 2.

Corollary 2 *Under the I2 account of the Stoic discipline of desires, the only cases where the two players can coordinate on the best outcome of the game (in utility payoffs) are the cases where either there exists a strict dominant strategy equilibrium, or there exists a unique (pure-strategy) strict Nash equilibrium. In the other cases, the two players cannot coordinate on the best outcome of the game, and, hence, cannot prevent welfare losses due to coordination failure. When multiple (pure-strategy) strict Nash equilibria exist, the two players are, under the I2 account of the Stoic discipline of desires, strictly indifferent between being in any of those (pure-strategy) strict Nash equilibria, so that there is no welfare loss from being in one equilibrium rather than in another, as long as players reach the same (pure-strategy) strict Nash equilibrium.*

Proof. See the Appendix. ■

Corollary 2 states that it is only in special cases that the I2 account of the Stoic discipline of desires suffices to coordinate agents on the best outcome of the game. It is only when there exists a strict dominant strategy equilibrium or a unique (pure-strategy) strict Nash equilibrium that the I2 account suffices to coordinate agents on the outcome that yields the highest utility payoffs. In all other cases, nothing guarantees coordination.

Unlike under the I1 account, the I2 account of the Stoic discipline of desires does not exclude the possibility of multiple (pure-strategy) strict Nash equilibria. When such a multiplicity occurs, the two players suffer from no welfare loss from coordination provided they are able to reach the *same* equilibrium. Indeed, the I2 account guarantees that each player is indifferent between all outcomes of the game where he plays his best reply to the other player's act. But this absence

of welfare loss requires that the two players are able to reach *the same* strict Nash equilibrium, something that cannot be taken for granted.

When one compares Corollary 2 with Corollary 1, one can see that the I1 account of the Stoic discipline of desires can achieve better results, in terms of coordination, than the I2 account. Indeed, under the I1 account, the Stoic discipline of desires suffices either to produce coordination, or to make coordination valueless. However, the same is not true under the I2 account. Under that alternative translation of the Stoic 'indifference to indifferent things', in some cases agents can coordinate on the best outcome of the game, but in most (other) cases they cannot do so, which yields coordination failures.

The intuition behind this negative result lies in the fact that, in comparison with the I1 account, the I2 account of the Stoic discipline of desires imposes fewer restrictions on the utility payoffs matrix. These fewer constraints do not suffice, in many cases, to guarantee that the two players will be able to coordinate on the outcome that yields the highest utility payoffs for each player. Under the I2 account, restrictions on the structure of the utility payoffs matrix are insufficient to produce coordination, due to the possible multiplicity of (pure-strategy) strict Nash equilibria. Hence, in that context, the usefulness of a 'focal point' is restored: Stoic agents need here to rely on some extra device in order to coordinate, as it is the case under standard economic rationality.

To illustrate this negative result, let us turn back to the Stag-Hunt game.

	Stag	Rabbit
Stag	(2, 2)	(0, 1)
Rabbit	(1, 0)	(1, 1)

Table 4: The Stag-Hunt game: material payoffs matrix.

Under the I1 account of the Stoic discipline of desires, the requirement of indifference between all outcomes where the player chooses the same act implies that the utility payoffs matrix exhibits only two utility levels for each player (one for each feasible act). As a consequence, it is the case either that there exists a strict dominant strategy equilibrium, or that at least one player is indifferent between all outcomes. This structure is such that either the two players have a dominant strategy and play it (in which case they reach an outcome that yields the highest utility payoffs), or, alternatively, that at least one player is indifferent between all outcomes of the game (in which case not achieving coordination does not cause any welfare loss).

Unfortunately, under the I2 account of the Stoic discipline of desires, the only requirement is a requirement of indifference, for a player, between all outcomes of the game where he plays his best reply to the other player's act. This requirement does not rule out the case of multiple (pure-strategy) strict Nash equilibria, unlike under the I1 account. It is thus possible, under the I2 account, that (Stag, Stag) and (Rabbit, Rabbit) are two strict Nash equilibria. In that case, the I2 account only requires that each player is indifferent between these two outcomes. But this indifference requirement does not help agents coordinating on any of the two equilibria. The only thing that I2 guarantees is that,

provided the two players can achieve the *same* outcome out of these two strict Nash equilibria, they suffer from no welfare loss from not being able to reach the other strict Nash equilibrium. But this indifference is of no help to be able to coordinate on the same outcome.

All in all, this section shows that whether or not the Stoic discipline of desires suffices to allow agents to achieve coordination on the best outcome of the game depends on how the Stoic requirement of 'indifference to indifferent things' is translated into the language of microeconomics. When the Stoic discipline of desires takes the form of the I1 account, it is the case either that agents achieve coordination on the best outcome, or that such a coordination is valueless. However, under the I2 account of the Stoic discipline of desires, coordination is not certain, and lack of coordination may cause welfare losses.

Hence, whereas, from the perspective of producing coordination, the Stoic discipline of acts is superfluous under the I1 account of the Stoic discipline of desires, this is not the case under the I2 account of the Stoic discipline of desires. Indeed, under the I2 account, agents do not spontaneously coordinate, and some shared view of the 'Common Good' is here necessary to produce coordination. *Unlike under the I1 account, the adherence of agents to the I2 account of the Stoic discipline of desires does not, on its own, suffice to produce coordination.*

These findings cast light on the (un)necessary role played by focal points in achieving coordination between Stoic players. Our results suggest that whether or not a focal point is useful for coordination purposes varies with the underlying microeconomic translation of the Stoic discipline of desires. Under the I1 account, it is either the case that coordination can be achieved, or the case that coordination is valueless. Hence agents do not need any focal point, unlike under standard economic rationality. However, under the I2 account of the Stoic discipline of desires, nothing guarantees that (valuable) coordination is achieved. Hence, in that alternative case, there is a key role for focal points.

Provided one reduces the power of morality to its capacity of coordinating individuals, those results cast also light on the power of Stoicism as a morality, and on the distinctive roles of the Stoic discipline of desires and the Stoic discipline of acts in the capacity of Stoicism to produce social conventions. Under the I1 account, social conventions can emerge without having to rely on the Stoic discipline of acts. Indeed, the I1 account either suffices to produce coordination between agents, or makes coordination valueless. But the same is not true under the I2 account of the Stoic discipline of desires. In that alternative case, the I2 account is not sufficient, on its own, to produce coordination. Hence the Stoic discipline of acts may be useful here, to avoid coordination failures. The particular form taken by the Stoic discipline of acts may vary across the coordination games considered, because each coordination problem may appeal to distinct values, and, hence, to distinct facets of the 'Common Good'.[38] Due

[38] For instance, in the Battle of the Sexes game, the values of the City that would be relevant would be the ones defining a valuable activity to be shared by the members of a couple, thus defining also what a 'good spouse' consists of. Similarly, in the Stag-Hunt game, the relevant values of the City would define what a 'good hunter' is, by restricting the scope of hunting activities. Such definitions, if incorporated in the Stoic discipline of acts, would allow Stoic

to space constraints, we will not consider that issue here, but it is important to highlight a fundamental difference between the two accounts of the Stoic discipline of desires concerning the potential role to be played by the Stoic discipline of acts in the production of social coordination.

5 Conclusions

Through which mechanisms can morality produce the 'cement of social stability'? The present study proposed to revisit that question, by examining the impact Stoic ethics on coordination between agents. For that purpose, we studied the implications of the Stoic discipline of desires - the requirement of wishing for nothing that is not under one's control (such as other players' acts) - in 2x2 simultaneous coordination games. We formalized the Stoic discipline of desires either as the I1 account (requiring indifference between all outcomes where the agent plays the same act) or as the I2 account (requiring indifference between all outcomes where the agent plays his best reply to other players' acts).

Our analyzes allowed us to derive three main results.

First, whether it is modelled as the I1 account or the I2 account, the Stoic discipline of desires imposes *a detachment with respect to material payoffs*. The Stoic discipline of desires imposes restrictions on the utility payoffs matrix, so that utility payoffs are not necessarily strictly increasing in material payoffs. Importantly, the kind of detachment from material payoffs induced by the Stoic morality varies across the microeconomic formalizations of the Stoic discipline of desires, and, also, across the coordination games considered. Under the I1 account, the detachment from material payoffs is such that the only thing that matters for an agent is the chosen act *per se*, no matter what its material consequences are. Under the I2 account, the detachment from material payoffs is such that the only thing that matters for a person is to play her best reply to other agents' acts, no matter what the material consequences of her act are. Thus the particular microeconomic translation of the Stoic discipline of desires leads to quite distinct forms of detachment from material payoffs.

Second, the detachment from material payoffs induced by the Stoic discipline of desires has strong implications for *the outcome of the game*. Whereas coordination games exhibit, under standard economic rationality, a multiplicity of (pure-strategy) strict Nash equilibria, this is not necessarily the case once players adopt Stoic morality. In particular, when players adopt the I1 account of the Stoic discipline of desires, the game cannot exhibit a multiplicity of (pure-strategy) strict Nash equilibria. But the impact of the Stoic discipline of desires on the outcome of the game varies with the modelling of the Stoic discipline of desires. The multiplicity of (pure-strategy) strict Nash equilibria is excluded under the I1 account, but can occur under the I2 account.

Third, *the capacity of the Stoic discipline of desires to produce coordination varies with the way in which the Stoic discipline of desires is formalized*. Un-

agents to reach coordination on the best outcomes of the game *even if* one adopts the I2 account of the Stoic discipline of desires.

der the I1 account of the Stoic discipline of desires, it is the case either that agents coordinate on the outcome that yields the highest utility payoffs for all, or that coordination is valueless. Thus the detachment from material payoffs induced by the I1 account suffices to avoid coordination failures. There is here no role for a focal point. However, under the I2 account of the Stoic discipline of desires, agents may suffer from coordination failures. Hence, if, following Binmore (2005), one considers morality as a device aimed at coordinating agents through the selection of a subset of Nash equilibria, only the I1 account of the Stoic discipline of desires is successful. The I2 account must, on the contrary, be complemented by other devices, such as a focal point or, within Stoicism, a discipline of acts based on a shared idea of the 'Common Good'.

In sum, Stoic ethics, by recommending a life in accordance with Nature, lays a strong emphasis on the relation between the whole and its parts. This strong emphasis on the relation between the society and each citizen makes the issue of coordination central to Stoic ethics. As this study showed, the mechanisms through which Stoic ethics can produce social coordination vary depending on how the Stoic discipline of desires - the requirement of 'indifference to indifferent things' - is defined. But beyond the different conditions under which coordination is achieved, it should be stressed that *each microeconomic translation of the Stoic discipline of desires leads to a distinct definition of the harmony between the whole and its parts*. Under the I1 account of the Stoic discipline of desires, the harmony between the whole and its parts is achieved thanks to the perfect independence of the different parts (whose behavior and welfare do not depend on what other parts do or not). On the contrary, under the I2 account of the Stoic discipline of desires, the harmony between the whole and its parts takes the form of a perfect responsiveness of each part to other parts. Harmony as independence *versus* harmony as responsiveness: it is a key contribution of the present analysis to disentangle these two Stoic representations of the ideal relation between the whole and its parts. Each of these views coincides with a distinct formal interpretation of Stoic ethics. Much work remains to be done, in the future, to further compare these two distinct views of the 'good life' and the 'good society', as well as their economic and societal implications.

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7 Appendix

7.1 Proof of Proposition 1

Take the utility payoffs matrix given by Table 2:

	A	B
A	$(\bar{u}, \breve{u})$	$(\bar{u}, \tilde{u})$
B	$(\hat{u}, \breve{u})$	$(\hat{u}, \tilde{u})$

The case where there are two (pure-strategy) strict Nash equilibria along the diagonal of the game can be excluded as follows. Indeed, when (A, A) is a (pure-strategy) strict Nash equilibrium, we have: $\bar{u} > \hat{u}$ and $\breve{u} > \tilde{u}$. When (B, B) is a (pure-strategy) strict Nash equilibrium, we have $\bar{u} < \hat{u}$ and $\breve{u} < \tilde{u}$. A contradiction is reached.

The case where there are two (pure-strategy) strict Nash equilibria off the diagonal of the game can be excluded as follows. When (A, B) is a (pure-strategy) strict Nash equilibrium, we have: $\bar{u} > \hat{u}$ and $\breve{u} < \tilde{u}$. When (B, A) is a (pure-strategy) strict Nash equilibrium, we have $\bar{u} < \hat{u}$ and $\breve{u} > \tilde{u}$. A contradiction is reached.

The case where there are two (pure-strategy) strict Nash equilibria along a column of the game can be excluded as follows. When (A, A) and (B, A) are two (pure-strategy) strict Nash equilibria, we must have: $\bar{u} > \hat{u}$ and $\breve{u} > \tilde{u}$, as well as $\bar{u} < \hat{u}$ and $\breve{u} > \tilde{u}$. There is a contradiction.

The case where there are two (pure-strategy) strict Nash equilibria along a row of the game can be excluded as follows. When (A, A) and (A, B) are two

(pure-strategy) strict Nash equilibria, we must have: $\bar{u} > \hat{u}$ and $\check{u} > \tilde{u}$, as well as $\bar{u} > \hat{u}$ and $\check{u} < \tilde{u}$. There is a contradiction.

We can thus rule out the existence of two (pure-strategy) strict Nash equilibria in the game. Moreover, the above rationales allow us also to rule out the case where more than two (pure-strategy) strict Nash equilibria exist. Hence, the I1 account of the Stoic discipline of desires rules out the multiplicity of (pure-strategy) strict Nash equilibria.

Let us now consider all possible outcomes of the game. Since there are three possibilities $(>, =, <)$ for the comparison of utility payoffs faced by player 1, and three possibilities $(>, =, <)$ for the comparison of utility payoffs faced by player 2, there are in total 9 possibilities.

Consider first the 4 cases involving only strict inequalities among utility payoffs. When utility payoffs satisfy $\bar{u} > \hat{u}$ and $\check{u} > \tilde{u}$, (A, A) is the dominant strategy equilibrium of the game. When utility payoffs satisfy $\bar{u} < \hat{u}$ and $\check{u} < \tilde{u}$, (B, B) is the dominant strategy equilibrium of the game. When utility payoffs satisfy $\bar{u} > \hat{u}$ and $\check{u} < \tilde{u}$, (A, B) is the dominant strategy equilibrium of the game. When utility payoffs satisfy $\bar{u} < \hat{u}$ and $\check{u} > \tilde{u}$, (B, A) is the dominant strategy equilibrium of the game.

Consider now the 5 cases involving some equalities among utility-payoffs. When $\bar{u} > \hat{u}$ or $\bar{u} < \hat{u}$ and $\check{u} = \tilde{u}$, player 2 is globally indifferent between all outcomes of the game, unlike player 1. Hence there is no (pure-strategy) strict Nash equilibrium. When $\bar{u} = \hat{u}$ and $\check{u} = \tilde{u}$, both player 1 and player 2 are globally indifferent between all outcomes of the game. Hence there is no (pure-strategy) strict Nash equilibrium. When $\check{u} > \tilde{u}$ or $\check{u} < \tilde{u}$ and $\bar{u} = \hat{u}$, player 1 is globally indifferent between all outcomes of the game, unlike player 2. Hence there is no (pure-strategy) strict Nash equilibrium.

7.2 Proof of Corollary 1

Take the utility payoffs matrix given by Table 2:

	A	B
A	$(\bar{u}, \check{u})$	$(\bar{u}, \tilde{u})$
B	$(\hat{u}, \check{u})$	$(\hat{u}, \tilde{u})$

If utility payoffs are such that there exists a strict dominant strategy equilibrium, for instance if $\bar{u} > \hat{u}$ and $\check{u} > \tilde{u}$, players will choose the associated dominant strategies (A), and thus players will coordinate on the outcome of the game that exhibits the best outcome for them in utility terms, which is, under $\bar{u} > \hat{u}$ and $\check{u} > \tilde{u}$, the outcome (A, A). The same kind of rationale holds for all cases where utility payoffs are such that there exists a strict dominant strategy equilibrium in the game.

On the contrary, if there exists no strict dominant strategy equilibrium, it must be the case, given Proposition 1, that at least one player is indifferent between all outcomes of the game. If only one player exhibits such a global indifference, the other player, who has a dominant strategy, will choose to play

that dominant strategy, whereas the other player will be indifferent between the two acts, and so between the two resulting outcomes of the game. Hence the lack of coordination on a given outcome of the game is not a source of welfare loss. If both players are globally indifferent between all outcomes of the game, they will not be able to coordinate on any outcome of the game, but this is not problematic, since both players are indifferent between all outcomes of the game. Thus there can be no welfare loss due to a coordination failure.

7.3 Proof of Proposition 2

The utility payoff matrix is:

	A	B
A	$(\bar{u}, \check{u})$	$(\grave{u}, \tilde{u})$
B	$(\hat{u}, \acute{u})$	$(\mathring{u}, \dot{u})$

To see why the I2 account does not exclude the existence of two (pure-strategy) strict Nash equilibria along the diagonal, note that, when (A, A) and (B, B) are (pure-strategy) strict Nash equilibria, we have: $\bar{u} > \hat{u}$ and $\check{u} > \tilde{u}$ as well as $\mathring{u} > \grave{u}$ and $\dot{u} > \acute{u}$, and, because of I2, $\bar{u} = \mathring{u}$ and $\check{u} = \dot{u}$. This case is possible.

To see why the I2 account does not exclude the existence of two (pure-strategy) strict Nash equilibria off the diagonal, note that, when (A, B) and (B, A) are (pure-strategy) strict Nash equilibria, we have: $\grave{u} > \dot{u}$ and $\hat{u} > \bar{u}$ as well as $\tilde{u} > \check{u}$ and $\dot{u} < \grave{u}$, and, because of I2, $\hat{u} = \grave{u}$ and $\acute{u} = \tilde{u}$. This case is possible.

The case where there are two (pure-strategy) strict Nash equilibria along a column of the game can be excluded as follows. When (A, A) and (B, A) are two (pure-strategy) strict Nash equilibria, we must have: $\bar{u} > \hat{u}$ and $\check{u} > \tilde{u}$, as well as $\bar{u} < \hat{u}$ and $\acute{u} > \dot{u}$. There is a contradiction.

The case where there are two (pure-strategy) strict Nash equilibria along a row of the game can be excluded as follows. When (A, A) and (A, B) are two (pure-strategy) strict Nash equilibria, we must have: $\bar{u} > \hat{u}$ and $\check{u} > \tilde{u}$, as well as $\grave{u} > \mathring{u}$ and $\check{u} < \tilde{u}$. There is a contradiction.

The case where there exists a strict dominant strategy equilibrium occurs in the following cases:

- when $\bar{u} > \hat{u}$ and $\grave{u} > \mathring{u}$, as well as $\check{u} > \tilde{u}$ and $\acute{u} > \dot{u}$, then (A, A) is the dominant strategy equilibrium;

- when $\bar{u} > \hat{u}$ and $\grave{u} > \mathring{u}$, as well as $\check{u} < \tilde{u}$ and $\acute{u} < \dot{u}$, then (A, B) is the dominant strategy equilibrium;

- when $\bar{u} < \hat{u}$ and $\grave{u} < \mathring{u}$, as well as $\check{u} > \tilde{u}$ and $\acute{u} > \dot{u}$, then (B, A) is the dominant strategy equilibrium;

- when $\bar{u} < \hat{u}$ and $\grave{u} < \mathring{u}$, as well as $\check{u} < \tilde{u}$ and $\acute{u} < \dot{u}$, then (B, B) is the dominant strategy equilibrium.

The case where there exists only one (pure-strategy) strict Nash equilibrium cannot be ruled out. For instance, (A, A) is a (pure-strategy) strict Nash equilibrium when $\bar{u} > \hat{u}$ and $\check{u} > \tilde{u}$. If $\grave{u} \leq \mathring{u}$, (A, A) is not a (pure-strategy)

strict dominant strategy equilibrium. If, in addition, $\acute{u} > \grave{u}$, (B, B) is not a (pure-strategy) strict Nash equilibrium. If Player 1's best reply to Player 2 playing B is to play B, we have $\mathring{u} > \grave{u}$ and, by I2, $\mathring{u} = \bar{u}$. Moreover, if Player 2's best reply to Player 1 choosing B is to play A, we have $\acute{u} > \grave{u}$, by I2: $\acute{u} = \breve{u}$. In sum, we have then: $\bar{u} = \mathring{u} > \hat{u}, \grave{u}$ and $\acute{u} = \breve{u} > \tilde{u}, \grave{u}$. That case is thus distinct from the previous ones. Under adequate conditions, any of the four outcomes of the game can be a unique (pure-strategy) strict Nash equilibrium of the game without being the strict dominant strategy equilibrium.

The case where there exists no (pure-strategy) strict Nash equilibrium cannot be excluded either. This occurs trivially when all utility payoffs are equal, that is, when $\bar{u} = \hat{u} = \grave{u} = \mathring{u} = \breve{u} = \tilde{u} = \acute{u} = \grave{u}$. This occurs also in cases such as when $\bar{u} < \hat{u}$, $\acute{u} < \grave{u}$, $\grave{u} > \mathring{u}$, as well as $\breve{u} > \tilde{u}$, or when $\bar{u} > \hat{u}$, $\acute{u} > \grave{u}$, $\grave{u} < \mathring{u}$, as well as $\breve{u} < \tilde{u}$.

7.4 Proof of Corollary 2

Consider the first sentence of Corollary 2. It can be shown that, in those two cases, the two players can, under I2, coordinate themselves on the best outcome of the game.

If utility payoffs are such that there exists a dominant strategy equilibrium, for instance, when $\bar{u} > \hat{u}$ and $\grave{u} > \mathring{u}$, as well as $\breve{u} > \tilde{u}$ and $\acute{u} > \grave{u}$, players will choose the associated dominant strategies (A), and thus players will coordinate on the outcome of the game that exhibits the best outcome for them in utility terms, which is, under these inequalities the outcome (A, A).

If utility payoffs are such that there exists a unique (pure-strategy) strict Nash equilibrium (but which is not a strict dominant strategy equilibrium), I2 guarantees that the two players reaching that unique Nash equilibrium achieve the highest levels of utility payoffs. We can illustrate this case by the case where: $\bar{u} = \mathring{u} > \hat{u}, \grave{u}$ and $\acute{u} = \breve{u} > \tilde{u}, \grave{u}$. In that case, there exists a unique (pure-strategy) strict Nash equilibrium (A, A). The utility payoffs achieved by the two players are thus $(\bar{u}, \breve{u})$. Interestingly, it is not possible for any player to achieve a higher utility payoff than at the Nash equilibrium.

But these cases are rather specific. In all the other cases mentioned in Proposition 2, I2 is not sufficient to allow agents to coordinate themselves on the best outcome of the game.

For instance, if utility payoffs are such that there exist two (pure-strategy) strict Nash equilibria, nothing guarantees that the two players will reach the outcome where each player has the largest utility payoffs. To illustrate this, take the case where (A, A) and (B, B) are strict Nash equilibria. We have: $\bar{u} > \hat{u}$ and $\breve{u} > \tilde{u}$ as well as $\mathring{u} > \grave{u}$ and $\grave{u} > \acute{u}$, and, because of I2, $\bar{u} = \mathring{u}$ and $\breve{u} = \grave{u}$. Note that these two equalities imply that if the two players reach one of the two (pure-strategy) strict Nash equilibria, they do not suffer from any welfare loss due to not being able to reach the other Nash equilibrium.

However, nothing guarantees, in the case of multiplicity, that the two players can coordinate on the same Nash equilibrium. If, for instance, Player 1 plays A and Player 2 plays B, the payoffs are: $\grave{u} < \mathring{u}$ and $\tilde{u} < \breve{u}$. The two players would

be better off either by making Player 2 play A (without any change in the act of Player 1), or by making Player 1 play B (without any change in the act of Player 2).