BETA
Bureau
d'économie
théorique
et appliquée

Documents de travail

«Knowledge acquisition or incentive to foster coordination ? A real-effort weak-link experiment with craftsmen»

Auteurs

Mathieu Lefebvre, Lucie Martin-Bonnel de Longchamp

Document de Travail n° 2020 – 09

Mars 2020

Bureau d'Économie Théorique et Appliquée BETA

www.beta-umr7522.fr

@beta_economics

Contact :
jaoulgrammare@beta-cnrs.unistra.fr

Université de Strasbourg · cnrs · Université de Lorraine · INRAE · AgroParisTech

Knowledge acquisition or incentive to foster coordination ? A real-effort weak-link experiment with craftsmen*

Mathieu Lefebvre†

Lucie Martin-Bonnel de Longchamp‡

Abstract

This paper presents a lab-in-the-field experiment with craftsmen working on renovation projects to assess the effect of training programs and incentive scheme on coordination and cooperation. Workers frequently fail to cooperate and coordinate their tasks when not supervised by a project coordinator. This is particularly important in the construction sector where it leads to a lack of final performance in buildings. We introduce two different incentives: a first contract paying craftsmen only according to their individual performance, and a second contract paying a group of three craftsmen with a weak-link payment according to the group's worst performance. In addition, we test these incentives on two different subject groups: one is composed of craftsmen trained to coordinate their tasks, and the others are not. The results suggest that trained subjects coordinate at significantly higher effort levels than non-trained subjects when facing an individual-based incentive. However, when facing a group-based incentive, non-trained subjects seem to "catch up" trained subjects in terms of coordination level, while these latter subjects do not significantly increase their performance level.

Keywords: Coordination, Real-effort weak-link experiment, Semi-Field Experiment, Individual Incentive, Group Incentive

JEL Classification: C01, C91, C92, C93

*The authors are grateful to Kene Boun-My for programming the experiment and helping in running the sessions. They would like to thank Dorothée Charlier, Julien Penin, Stéphane Robin et Sandrine Spaeter for their very helpful comments and suggestions. This project was funded by the ADEME and Region Grand Est.

† *Corresponding author*:BETA, University of Strasbourg and CREPP, University of Liege, 61 Avenue de la Foret Noire, 67085 Strasbourg, France; E-mail: `mathieu.lefebvre@unistra.fr`.

‡BETA, University of Strasbourg, 61 Avenue de la Foret Noire, 67085 Strasbourg, France; E-mail: `luciembdl@gmail.com`.

1 Introduction

In a lot of situations, coordination is a key to success for teams. For example, a sports team can have the best athletes, or a business the most talented employees, if they cannot coordinate their actions towards the goal, they will not succeed. Although necessary, specialization and skills are not always sufficient to achieve the best outcomes.

In this paper, we present the results of a real-effort lab experiment in which we compare, in a within-group design, individual-based and group-based incentives to coordinate on high effort levels for craftsmen working on renovation projects. The originality of the experiment is that it gathers "real" workers from the construction sector where, given the weak-link property of the tasks, coordination is essential, (i.e. one worker fails to achieve her goal and all the work is spoiled). Furthermore, we not only compare the effects of different incentives but also look at the effect of training to coordination by comparing subjects having been trained to coordination exogenously and others who are not.

A long literature has shown that in many different situations teams end up coordinating at inefficient outcomes (Van Huyck et al., 1990; Weber et al., 2001; Brandts and Cooper, 2006, ...), and thus, failing to coordinate. Such coordination failure can be due to subject-pool effects (Engelmann and Normann, 2010), the lack of possibility to choose its team members (Riedl et al., 2016), team heterogeneity in terms of productivity (Meidinger et al., 2003), free-riding, even when cooperation is a dominant strategy (Holmstrom, 1982) or strategic uncertainty (Van Huyck et al., 1990).

Importantly, *strategic uncertainty* may make incentive contracts "fragile", particularly in environments presenting a weak-link property (Van Huyck et al., 1990; Cooper et al., 2018). This uncertainty arises (1) when subjects find it too risky to exert a high-effort level (i.e. choosing the payoff-dominant effort) while being not sure about their team members' strategies, and (2) when subjects keep in mind earlier periods of the game. For instance, it has been shown that when earlier outcomes were low, because of one team member choosing a low effort, subjects find it hard to trust the others to coordinate at high effort levels. As exposed by Knez and Simester (2001), a typical example of a weak-link environment is the take-off of an airplane. Before departing, many operations and procedures have to be fulfilled (e.g. cleaning, fueling, loading of the food, security checks, loading of the luggage, passenger boarding, ...). All these tasks are complementary, because if one of these is not well executed, the plane will not take-off on time. Furthermore, some employees' high efforts may be in vain if only one of them does not perform well in her task. Such a linkage corresponds to a "production technology of the weak-link type". It means that a firm's outcome (e.g. on-time departure) depends on the employees' worst performance. In other words, to achieve a high performance, every employee *must* coordinate on exerting high effort levels. As the outcome depends on the worst performance (i.e. the minimum effort) of the members of a team, so does everyone's payoff. Such a contract is thus appropriate to incentivize towards efficient coordination among the employees.

However, using laboratory experiments[1], Van Huyck et al. (1990) have shown that such a mechanism is only efficient for very small groups of workers (i.e. two players). Additional mechanisms are thus required to increase coordination, especially in larger groups. Here again, the experimental literature has pointed out five different tools that are effective to facilitate coordination in weak-link situations. First, *costless pre-play communication* has been shown to be effective in facilitating coordination (see, for instance, Cooper et al., 1992; Blume and Ortmann, 2007). When subjects can send messages to their team members, before choosing their action, it reassures players on the team members' intentions to target high effort levels, and helps them overcome strategic uncertainty. Secondly, *endogenous group formation*, where subjects can endogenously choose their group members, has also proved to be very effective. Particularly, Riedl et al. (2016) show how exclusion can be a disciplining device. When high performers can exclude low performers, the latter increase their effort to avoid being excluded. Chen (2017) also points out a social identity effect such that "a person who chooses her own group will more strongly identify with that group, and care more about the outcome of the group's other members". Thirdly, Bornstein et al. (2002) show that *competition between groups* is also effective in increasing coordination. They show that members of a group of seven, were coordinating at much higher levels when additionally confronted to an inter-group payment. In such a competition, the group presenting the overall weakest effort level was paid nothing, whereas the other one was paid according to the weakest performance of their group members. The authors show that even when paying the "less efficient" group less (instead of nothing) than the other group, inter-group competition was still significantly more effective (but slightly less) than no competition. Fourthly, Chaudhuri et al. (2009)

[1] The weak-link technology has been studied in the lab through the so-called weak-link games, also called minimum effort games.

have proven the effectiveness of *inter-generational advice*. In their game, they simulate non overlapping generations with groups playing non simultaneously. When the first range of groups are done, they can pass on advice (in the form of written messages) to the succeeding groups (i.e. the next generation). Chaudhuri et al. (2009) explain that the second generation must start at an efficient level in order to maintain it in the following periods. Subjects, thus, have to receive the right advice and choose the right action. To achieve this, the authors show that the mechanism is most effective when the advice given from one generation to the next, is shared to everybody and made common knowledge. A last efficient mechanism is the *priming of subjects' identity*, tested by Chen et al. (2014). More specifically, when priming a minority identity (e.g. Asian, Caucasian), subjects are less likely to coordinate at high effort levels, whereas priming a school identity significantly increases efficient coordination and high payoffs (Chen et al., 2014). Thus, identity and subjects' prejudices play an important role in coordination.

On the grounds of these evidence, this paper presents a weak-link game where the *weak-link* is the worst performance exerted by the member of a group of three players. Our subjects are craftsmen working on renovation construction sites. In a within-group design, we introduce successively an *Individual-based Incentive*, and a *Group-based Incentive*. Following Bortolotti et al. (2016), we implement a real-effort task instead of a chosen-effort set-up for two reasons. First, the "selection" of the highest effort with the *Individual Incentive* (and thus the efficiency of this incentive) would be trivial in a chosen-effort set-up. Second, an effort chosen by the subject might not represent his real abilities, and thus the effort he would exert in reality. This can be problematic for the external validation of our results. As mentioned by Bortolotti et al. (2016), chosen-effort set-ups might point to the possible limited external validity of past collected data on weak-link games.

The novelty of our experiment is twofold. First, we do not only compare individual and group incentive for active workers from the construction sector, but we specifically assign subjects' individual performance targets they should achieve. Brandts and Cooper (2007) find that allowing communication between managers (the experimenter) and employees (players) leads to increased efficient coordination and higher payoffs. They recommend that managers request a specific effort level. In addition, contrary to Cooper et al. (2018), we did *not* increase the difficulty of escaping a *performance trap* (i.e. be stuck at low effort levels) by keeping the other team members' past effort levels unobservable. Second, we look at the impact of exogenous training courses on group coordination. More specifically, the pool of subjects is made of construction craftsmen, working, among others, on (low energy) renovations, in the Region Grand Est, in north-eastern France.[2] Some of these subjects have been incentivized to coordinate their efforts (and tasks) through a training course on efficient coordination (the so-called *DORéMI* program). This training course teaches the craftsmen (1) efficient low energy renovation techniques, (2) how to coordinate their complementary tasks with other craftsmen, and (3) the importance of coordination to achieve high performance. Our control group is composed of craftsmen who did not participate in this training course. We are thus interested in identifying possible behavioural differences between trained and non trained subjects, and seeing if a simple mechanism of exogenous training about coordination is efficient to achieve coordination at high effort levels.

Our paper also contributes to the literature on coordination dynamics by providing evidence of the effect of individual and group weak-link incentives on effort provision and coordination, when subjects have to exert a real effort rather than to choose their action. To our knowledge, Bortolotti et al. (2016) are the first and only one, until today, having implemented *Individual* and *Group Incentives* in a real-effort weak-link game.

Practically we test subject-pool effects, and more specifically, the coordination capacity between trained and non trained craftsmen. Hence, we implement a "2 x 2" experimental design, where we compare how both subject groups act when facing both treatments (*Individual-based Incentive*, and *Group-based Incentive* with weak-link payment). In other words, we want to determine (1) if it is possible to incentivize towards more coordination through a weakest-link contract (that would make all the craftsmen of one project responsible toward correctly accomplishing a common work), and (2) whether this *Group-based Incentive*[3] has the same incentive effect on both subject groups.

The subjects had to count the number of ones in a table of 50 randomly selected ones and zeros. They had to resolve as many tables as possible in a given time period, by trying to attain individual performance targets (a minimum acceptable target, and a maximum ideal target) in terms of number of tables to resolve. We normalized the cost-of-effort across the

[2] A renovation site presents the weak-link property. Every craftsman has his own speciality and task to renovate a building. Their tasks are complementary to achieve an efficient final energy performance. Yet, when one of the craftsmen fails to efficiently execute his task, the buildings final performance will be (negatively) impacted. It thus depends on worst performance of all the craftsmen working on the renovation site.

[3] The aim of the *Group-based Incentive* is not to teach craftsmen *how* to coordinate their tasks, but rather to seek a common high effort level to achieve low energy performance of the renovated building.

subjects by scaling the targets to their actual individual abilities, in a first stage. Every subject thus had his or her own targets, and had to exert a substantial effort to attain the ideal target. In the *Individual treatment*, subjects experienced no strategic uncertainty and were paid according to their individual performance. In the *Group treatment*, subjects were randomly assigned in groups of three, which stayed unchanged for the rest of the experience, except that trained subjects were assigned with other trained subjects, and the same was done for non trained subjects. They were paid according to a weak-link payment function, that is, the worst performance exerted by all the members of their group. Every group member thus received the same payment. Equal than in "standard" weak-link games, subjects experienced strategic uncertainty.

The main results of the experiment suggest that trained subjects coordinate at significantly higher effort levels than non-trained subjects when facing an individual-based incentive. However, when facing a group-based incentive, non-trained subjects seem to "catch up" trained subjects in terms of coordination level, while these latter subjects do not significantly increase their performance level. This result suggests that proposing a group-based incentive to subjects who have previously been trained on coordination, does not yield higher coordination levels. Indeed, their exogenous sensitivity to successful and efficient coordination seems to be a sufficient mechanism to incentivize towards common high effort levels. Yet, when enforcing the subjects to play sequentially with a given amount of time for the entire group (i.e. time constraint), trained subjects playing before the last one in the group, seem to adopt a self-restricting strategy, so that they perform significantly worse than when facing an individual-based incentive. It seems that the possibility to not achieve efficient coordination causes them stress. Hence, trained subjects voluntarily target lower performance levels to have the certainty to reach a sufficient high performance, so that the last member in the sequence order has enough time to reach his or her acceptable target. Such a strong effect of time constraint is not visible on the coordination behaviour of non trained subjects. Finally, our results suggest that the tested incentives have different impacts on the subject groups' worst performance levels. Indeed, individual-based incentives may be better suited for trained subjects to achieve the highest average worst performance, whereas group-based incentives seem to be more efficient to increase non trained subjects' worst performance. However an important caveat regarding our results on the difference between trained and non trained subjects is the small sample of trained craftsmen that showed up.

The rest of the paper is structured as follows. Section 2 describes the experimental design. Section 3 presents the hypotheses of the paper, and Section 4 exposes descriptive statistics and the empirical results. Finally, in Section 5 we conclude after a discussion of our results.

2 Experimental design

The experiment consists of a real-effort game played repeatedly. Following Abeler et al. (2011) and Marchegiani et al. (2016), in all periods, subjects were confronted with a tedious and focus-demanding task, which consists of counting the number of ones in tables composed by 50 randomly placed ones and zeros. This real-effort task has various advantages: (1) no prior (economic) knowledge is needed from the subjects, (2) nearly no learning is possible from the subjects throughout the game periods, (3) subjects' performance is measurable without difficulty, (4) the boringness ensured a positive cost-of-effort from the subjects, and (5) the pointlessness ensured that no subject could derive any benefit (e.g. personal utility) from it. It ensures that the subjects all have the same utility by participating to this experiment. Furthermore, an important advantage of this simple task is that it is clearly artificial and the output has no value to the experimenter which should reduce tendency for subjects to increase their effort as a way to reciprocate for payments offered by the experimenter.

The experiment is divided in two main phases: an individual productivity elicitation phase and a phase which consists of repeated work. These two phases are detailed below, but Figure 1 presents in short the timing of a session. We first elicit individual productivity in Stage I, in order to set individual production targets. Then, Phase II comprises four successive stages, where subjects have to execute a real-effort task, wherein the incentives change from stage to stage.

Throughout the experiment, subjects were randomly assigned to a group of three players having the same exogenous training on coordination. The groups were fixed until the end of the session and it was not possible for a subject to know the identity of the other members of the group. During the experiment, subjects accumulated payoffs in ECU, with the conversion rule 100 $ECU = 1$ euro. The final gains were distributed anonymously in cash after having answered a post-experimental questionnaire in the End Phase.

Subjects were told about the total number of stages from the beginning, however, detailed instructions[4] were read out loud by the experimenter before starting each stage, to ensure that the game's description was common information. Subjects had the possibility to simultaneously read these instructions on paper and ask any question to the experimenter before beginning a stage.

Figure 1: Flow of the experiment

2.1 The individual productivity elicitation

After a short (unpaid) training of two minutes (120 seconds), where subjects could become familiar with the task and the manipulation, subjects had five minutes (300 seconds) to count as many tables as possible. In order to elicit individual productivity, subjects were offered a pure piece-rate compensation scheme. For each table correctly processed, they receive 10 ECU. The gain from this first phase is then given by $\pi_i^{elicitation} = 10 \cdot P_{elicitation}$, where $P_{elicitation}$ is the number of tables resolved. Wrong answers were not penalized[5] and the number of tables resolved was displayed on the screen during the task. The screen also displayed a timer to make subjects aware of the time running.

The number of tables they correctly counted was used to design a feasible contractual effort in subsequent parts of the experiment, but subjects were not informed about this. As in Marchegiani et al. (2016) and Cosaert et al. (2019), this phase permitted to normalize the cost-of-effort for the task across players by scaling the *individual performance targets*, assigned in Phase II, to the subjects' actual abilities.

[4]The instructions are available in French in Appendix A.

[5]The subjects had three attempts to solve a table. After three errors, a new table appeared. This was done in order to prevent subjects to guess the number of ones too many times in a row. To prevent guessing, Abeler et al. (2011), for example, deducted a piece-rate of 10 cents when subjects failed in all three attempts.

2.2 The repeated real-effort game

In Phase II, subjects play three stages repeatedly and the task is again to count ones. Instead of being paid piece-rate as in the previous phase, subjects are offered successively an individual-based and a group-based incentive. For reasons that are exposed below, the three stages are of different time length. In the Stages 1 and 2, subjects had to execute the task during five periods of two minutes (120 seconds) each.[6] The main difference between both is the incentive given to the subjects: either individual or group-based. In Stage 3, the subjects also face a group-based incentive but they do not play simultaneously. They are given six minutes (360 seconds) for the entire group, and the sequence of their intervention is imposed. After a group member reaches his or her acceptable target and passes her turn, or after he or she achieves his or her ideal target, the next subject executes the task with the remaining time.

2.2.1 Acceptable and ideal performance targets

The incentives offered to subjects are based on targets that were assigned to each subject. Indeed, in the beginning of Phase II, subjects were assigned two different individual targets they had to attain in terms of number of rightly counted tables. These targets were set individually following the productivity elicitation in Phase I. During Phase II, they were asked to at least reach the (1) *acceptable performance target*, denoted $P_i^{acceptable\,target}$ (it corresponds to 90% of the productivity exerted in Stage 1), and at best reach the (2) *ideal performance target*, denoted $P_i^{ideal\,target}$ (it corresponds to 110% of the productivity exerted in Stage 1).

In a two minutes period, individual performance targets to pursue were determined as follows[7]:

$$P_i^{acceptable\,target} = 90\% \cdot \frac{P_i^{elicitation}}{5\,min} \cdot 2\,min \tag{1}$$

$$P_i^{ideal\,target} = 110\% \cdot \frac{P_i^{elicitation}}{5\,min} \cdot 2\,min \tag{2}$$

[6]For the sake of simplification and contrary to Bortolotti et al. (2016), we decided to not sell extra time to subjects to achieve any of the targets.

[7]$P_i^{acceptable\,target}$ was rounded downwards, whereas $P_i^{ideal\,target}$ was rounded upwards to prevent having the same acceptable and ideal targets for some subjects.

Subjects were not made aware about how their targets had been determined, nor that every participant had different targets, according to their performance in the elicitation phase. We did not give them this information and announced the targets only in Phase II, in order to prevent for strategic behaviour in Phase 1. We justify the 10% discount rate on the acceptable target by the tiredness that can result after repeating the task over and over. As mentioned by Marchegiani et al. (2016), the (acceptable) target should be achieved by exerting a high, but not too high, effort on the task[8]. The ideal target, however, has voluntarily been determined to be more difficult to achieve. Only very motivated subjects would thus try to attain it after having reached the acceptable target.

Why *two* different performance targets? Assigning subjects two different targets is a particularity of this experiment. To our knowledge, we are the first one to propose this. In a socio-economic environment, workers have tasks to execute. They can execute the minimum that has been required by their employer, or they can go further and perform their task even better. For example, a window installer can decide to "correctly" install a window, but he can also decide to install it in a air-tight way to gain energy efficiency of the building. Such tasks are often complementary with tasks of other co-workers. To continue our example, if not every co-worker achieves air-tightness, the energy performance of the building is decreased. We want the subjects to coordinate on the highest possible effort level. Thus, assigning them only one target corresponding to the highest level may not permit to determine whether the subject is willing to achieve the best possible performance, or just the acceptable one. By introducing two performance targets (acceptable and ideal), we can make the following observations. When a subject executes his task until reaching his acceptable performance target $P_i^{acceptable\ target}$, it might indicate that he is willing to coordinate on an acceptable high effort level. However, when he continues to execute it to reach his ideal performance target $P_i^{ideal\ target}$, it might indicate that he is willing to coordinate on an even higher effort level, that is, an ideal very high effort level. In other words, he wants to coordinate on a common goal with the other group members. Concerning the targets' names, we claim that, psychologically, reaching an "acceptable" target already represents an achievement. Wanting to continue until reaching an "ideal" target may indicate the willingness of subjects to accomplish their task in the best possible way, without being satisfied with the minimum acceptable.

[8] Marchegiani et al. (2016) only assigned the subjects the equivalent of our acceptable task in their experiment.

2.2.2 Individual-based and group-based incentives

As explained above, Phase II is composed of three stages. In Stage 1, subjects played successively five periods of two minutes. In each period, their payoffs were determined according to an individual-based incentive. Following Bortolotti et al. (2016), the *Individual Incentive* for subject i in Stage 1, denoted π_i^{S1} is defined as follows:

$$\pi_i^{S1} = F + B \cdot \frac{ResolvedTables_i}{P_i^{acceptable\,target}} \tag{3}$$

were $ResolvedTables_i$ is the number of correctly counted tables by subject i, that is, the individual performance. We fixed $F = 100$ and $B = 800$. The higher the individual performance, the higher the gain. Contrary to Brandts and Cooper (2006), we did not impute the payment by the individual cost-of-effort, because our real-effort set-up permitted to normalize the cost-of-effort across the subjects.

In Stage 2, subjects also played successively five rounds of two minutes, but in each round, their payoffs were determined according to a group-based incentive. This incentive introduces a weak-link mechanism in order to induce subjects to coordinate on the highest effort level. The weak-link here corresponds to the worst performance of the three members of the group. The payoffs for a subject i in Stage 2 is defined as follows:

$$\pi_i^{S2} = F + B \cdot \min_{i \in 1,2,3} \left[\frac{ResolvedTables_i}{P_i^{acceptable\,target}} \right] \tag{4}$$

Incentives (3) and (4) correspond to a *high performance pay*, that is, low fixed payment F and high incentives B to coordinate at, respectively, execute, high effort levels (Cooper et al., 2018).[9]

In Stage 3, subjects faced the same group-based incentive (4). However, they do not play five rounds of 2 minutes each, but instead, execute the task during three periods of six minutes (360 seconds) each. The six minutes where however assigned to the entire group, and subjects had to play sequentially, contrary to before. They played one after another, with an enforced sequence. In each period, subjects had different playing sequence. Individual performance targets were kept unchanged. Indeed, by dividing the six minutes by three (group members), every group member should optimally play two minutes. Subjects had to

[9] A *low performance pay*, on the contrary, has a high fixed payment F and low incentives B to coordinate at, or simply execute, high effort levels.

reach at least $P_i^{acceptable\,target}$. Once attained, a button appeared on the screen to hand over to the next group member at any moment. In case they continued until maximum $P_i^{ideal\,target}$, the handing over occurred automatically.

This stage of the experience has the particularity to indirectly enforce the task chronology (and thus their coordination) among subjects. It was thus very important for the subjects to be attentive to give the last player enough time to reach his or her target. Otherwise, every group member would be impacted by receiving a low payment. Hence, the design of Stage 4 adds a time constraint, which results in a severe "punishment" for the entire group if not considered and respected. This time constraint also adds pressure on the subjects to work quickly to achieve their target.

As explained by Bortolotti et al. (2016), although we measure subjects' real effort, our *Group Incentive* (4) shares important characteristics with standard weak-link games[10]. First, the bonus B variates with the firm's (e.g. renovation work) worst performance. Second, subjects (e.g. employees, craftsmen) will receive a positive payment F, even when exerting no effort, or when one of the group members decides not to work. Thus, if realising the task represents a positive cost-of-effort for the subjects, they will only exert a positive effort when they expect every group member to do the same. Furthermore, the subjective cost-of-effort certainly being lower than the bonus amount B (because B has been set to a relatively high amount compared to F), successfully coordinating on reaching at least its acceptable target results in higher payments for all the group members. We thus replicate the trade-off of standard weak-link games, experienced by the subjects, between choosing the risky strategy (i.e. successfully coordinating on exerting high effort by at least achieving the acceptable target) and the safe strategy (i.e. exerting low effort because of the uncertainty that the other group members will exert a positive effort).

2.3 Procedures

Subjects were actual craftsmen working, among other, on energy renovations in the Region Grand Est in north-eastern France. They were recruited by the means of coordinators of renovation platforms located in the entire region. They were invited to assist to an information meeting organized by the Region, where they were told that they could also participate in an economic experiment. The experiment was conducted with mobile devices (tablets) of the

[10]Recall that they generally consider chosen-effort of subjects.

Laboratory of Experimental Economics of Strasbourg (LEES), using the software EconPlay[11].

A total number of 36 subjects participated. The sessions were organized in different locations of the Region. The first session took place in Saint-Dié-des-Vosges in October 2018, with 27 non-trained (to coordination) craftsmen (75%).[12] The subject group with trained craftsmen was tested in a session organized in Sélestat in December 2018, with 9 subjects (25%). Thus, each subject was selected in only one subject group. The entire panel was composed of 9% of women, and 91% of men, who were on average between 41 and 50 years old. Some heterogeneity was to be observed in terms of education level across the panel, so that 34.28% had a higher education, and 5.71% had no education at all. Futhermore, there was no significant difference between trained and non-trained subjects in terms of revenue. The average earnings in the experiment was 32.91 euros (going from 27 to 39 euros). One session lasted one hour and a half, including time for instructions and the post-experience questionnaire.

Our experiment is thus a semi-field experiment, with a controlled environment, but with professionals instead of students. We had two main subject groups: (1) trained on coordination (denoted group T), and (2) non trained on coordination (denoted group NT) on a low energy renovation site. As explained above, craftsmen of subject group T were trained through the *DORéMI* energy renovation training course, which stands for "Operational Device for the Energy Renovation of Individual Houses". Table 1 hereafter, summarizes the "2 x 2" design of our experiment.

Table 1: Experimental "2x2" design

Subject Group / **Treatment**	*Trained to coordination (T)*	*Not trained to coordination (NT)*
Individual-based incentive (I)	T - I	NT - I
Group-based incentive (G)	T - G	NT - G

Between the periods, subjects had the possibility to briefly rest. During this pause, sub-

[11] www.econplay.fr.

[12] One of the subjects left during the session because he had difficulties to read the ones and zeros in the tables. To permit the other players of its team to continue the experiment, we replaced the missing subject by one our colleagues of the University of Strasbourg. However, to ensure this member did not bias our results, we decided to eliminate its observation in the final database.

jects received statistics on the number of tables they had to solve to attain their acceptable (resp. their ideal) target, the number of tables resolved during the period, the percentage of their acceptable (resp. ideal) target achieved, and their gain for the period. In Stage 3 and 4, where a group incentive was given, they additionally received statistics on the percentage of the acceptable (resp. ideal) target their two group members achieved respectively. Evidence of the efficiency of providing subjects' with information about the members of their own group's previous strategy choices, is mitigated in the literature. Engelmann and Normann (2010) find that it deteriorates efficient group coordination in groups of four, but that it is an efficient instrument in groups of six players. Berninghaus and Ehrhart (2001) find the same latter result with groups of eight, and Brandts and Cooper (2006) with groups of four subjects. Although our experiment analyses groups of only three players, we decided to implement this feature for two reasons. First, it is a more realistic real life situation, and, second, Van Huyck et al. (1990), among others, have shown that smaller groups tend to coordinate more efficiently than larger groups. We, however, choose to not show them information about other group's result, as Chen (2017) shows that it has no significant effect in improving coordination.

3 Predictions

We are interested in studying the difference in effort provision when given different types of incentives, namely, an *Individual-based Incentive* (I) and a *Group-based Incentive* (G). Furthermore, as we test these incentives on actual craftsmen, we analyse their coordination behaviour, whether they have been professionally trained for coordination in their work (T), or not (NT).

Participating, for instance, in a training course on the importance of coordination and its application to achieve efficient outcomes, contributes to make individuals more optimistic about coordination.[13] It aims to increase their positive beliefs about the efficiency of coordination. Hence, subjects presenting such a background (i.e. T) certainly are optimistic about the *chance* to achieve coordination at high and efficient levels. As long-term outcomes in coordination games are largely driven by initial beliefs (see Van Huyck et al., 1990), Cooper et al. (2018) state that assigning a *high performance pay*[14] to "optimists" (e.g. trained subjects)

[13]Note that we have in mind that the fact of being inclined to adopt a cooperative behaviour can also be inherent to a person. We therefore asked a specific question in the final questionnaire to be able to control for this aspect

[14]Recall, as explained in Section 2, that the incentive given to the subjects are a *high performance pay*: low

increases the chance of efficient coordination. Thus, as we assign a high performance pay to both of our subject groups (T and NT), it should intuitively be more efficient on subjects T than on subjects NT. This brings us to the first hypothesis, stated hereafter:

Hypothesis 1 *The average effort in subject groups T is higher than in subject groups NT.*

Considering more specifically the *Group-based Incentive*, it has been designed to induce efficient group coordination. In the weakest-link game, every subject wants to achieve a common goal. Moreover, they are all incentivized to play their "full part" in reaching this common goal, when assured that all the others will also play their "full part" (Barrett, 2016). The game has multiple (pure strategy) Nash equilibria, where subjects of a group have to coordinate and choose the *same* strategy. Indeed, this game does not allow for free-riding. If an individual is the only one to free-ride, he will be "punished" by receiving a low payment, as well as all his team members'[15], according to his achieved performance. He thus has no interest in doing so. Moreover, free-riding is offset by peer pressure (Kandel and Lazear, 1992; Meidinger et al., 2003). The weak-link of the *Group-based Incentive* actually exhibits an inherent peer pressure which encourages coordinated behaviour. Peer pressure has been found to be an efficient solution against coordination failure (Kandel and Lazear, 1992; Carpenter et al., 2009; Corgnet et al., 2015; Falk and Ichino, 2006) among subjects. Kandel and Lazear (1992) stress that the shame felt by the subjects performing worse than the group average, works as an efficient mechanism, and permits to understand the effectiveness of peer pressure. Falk and Ichino (2006) state that when pay is based on group incentives, peer pressure might be decisive in increasing performance, especially if group members can directly exert peer pressure in the form of sanctions. In our game, the peer pressure is exerted through the incentive design in the form of "global" punishment (i.e. low payment). The enhanced performance effect described by Falk and Ichino (2006) may nevertheless also occur in our game, especially because by exerting on low effort and thus achieving a low performance, the strategic uncertainty of the other members will increase. They will thus tend to choose the less risky strategy of a weak.link game, which is, not exerting a high effort. Otherwise, they might work hard without being paid. This situation will lead to a *productivity trap*, also called *performance trap*, mentioned, among others, by Brandts et al. (2007) and Cooper et al. (2018). Contrary to the *Individual-based Incentive*, once uncertainty about the others' future efforts is too high,

fixed payment and high incentives to coordinate at, respectively, to execute high effort levels.

[15] Recall that subjects are assigned to the same group with the same members during the entire experiment.

coordinating on high effort levels is very difficult without the introduction of a controllable instrument as for example communication (through the intervention of an external manager (Brandts and Cooper, 2007), formal punishment (Dai et al., 2015; Vranceanu et al., 2015), or letting the subjects choose their group partners (Riedl et al., 2016; Chen, 2017). To avoid falling in a performance trap, subjects have thus no interest in exerting low effort levels. The peer pressure and the indirect punishment resulting with the *Group-based Incentive*, but being absent in with the *Individual-based Incentive*, the former incentive should incentivize to exert higher effort levels on average than the latter one, especially if subjects have never been trained to coordinate. This brings us to Hypothesis 2 stated hereafter:

Hypothesis 2 *In the NT group of subjects, the average effort with the Group-based Incentive is higher than with the Individual-based Incentive.*

However, as explained for Hypothesis 1, assigning a high performance pay (which corresponds to both of our treatments I and G) to subjects T, increases the chance of coordination at high effort levels. Recall that their training may have made their prior beliefs more optimistic about efficient coordination. Thus, the *Group Incentive* is not as incentive on subjects T than on subjects NT, who on average have a less optimistic prior belief on efficient coordination. In other words, the *Group Incentive* might not be more incentive on subjects T than the *Individual Incentive.* This brings us to our last hypothesis, stated as follows:

Hypothesis 3 *In the T group of subjects, the average effort with the Group-based Incentive is not higher than with the Individual-based Incentive.*

4 Results

This section presents the main results of our experiment. We first look at some descriptive characteristics of our sample of craftsmen. We then run a series of non-parametric tests in order to validate our hypotheses. An econometric estimation of the drivers of individual performance confirm our predictions and concludes this section.

4.1 Descriptive statistics

In our sample of craftsmen, 74% are self-employed and 26% work for a general contractor in the building industry[16]. 89% of the involved firms are "RGE" labeled, which stands in French for "Recognized as environmentally responsible". This label is mandatory in the energy renovation sector in France, in order for the project owners (i.e. clients) to apply for governmental financial aids. This high percentage indicates that, in order to stay competitive and attractive in the energy renovation sector, a firm must apply for this environmental label. Furthermore, 20% of our subjects are specialized in more than one trade, and nearly half of the panel has been working in the building sector for more than 20 years.

In the final questionnaire of the experiment, we ask them a series of general and specific questions about their work as well as coordination at work. Interestingly, it appears that their opinion about coordination depends on the presence or absence of a project manager during the execution phase. The role of a project manager is to help the craftsmen to coordinate their different tasks and interventions on a construction/renovation site. In *presence* of a project manager, T and NT craftsmen evaluate the difficulty to coordinate their tasks during the work, on average around 4.66 on a scale going from 1 to 10, with 10 finding it very difficult to coordinate. This is a rather low estimated difficulty, which tends to show that the intervention of a project manager may reassure workers. Yet, *without* project manager, T subjects find it significantly *more* difficult than NT to coordinate their task with others[17]. A possible explanation may be that T subjects are more sensitive to efficient and successful coordination than NT ones. By answering this question, they may thus have thought in the difficulty of achieving an efficient coordination, resulting in the expected outcome in terms of building performance.

Nevertheless, in *presence* of a project manager, T subjects feel significantly more motivated in trying to coordinate their tasks with others than NT subjects. *Without* manager, however, there is no significant motivation difference between both subject groups. Note that, on average, the subjects of the panel estimates their confidence in their co-workers to be 6.54 on a scale going from 1 to 10. This mitigated confidence level may explain the lessened motivation towards coordination in the absence of a project manager. Yet, in general, T subjects feel significantly more enthusiastic than NT subjects, to coordinate their interventions with their

[16] General contractors in the building industry include several trades, and can thus propose complementary works to project owners willing to renovate their building.

[17] On average, 6.57 out of 10 for T, compared to 4.88 out of 10 for NT craftsmen.

co-workers.

All in all, all subjects believe that it is (very) important to try to coordinate the tasks of all the craftsmen present on a project, and attaches great importance to its reputation in the energy renovation sector.

4.2 Non-parametric analysis

We first start by looking at existing differences in terms of productivity, then we present the average performance according to compensation schemes and training. Unless specifically noted, we report the significance levels of a two-sided Wilcoxon-Mann-Whitney rank-sum test.

4.2.1 Productivity elicitation

In Phase I, during the individual productivity elicitation, both subject groups (T and NT) had five minutes to resolve as many tables as possible. Figure 2 displays, for both groups, the average number of tables they were able to resolve rightly, and those validated with the wrong number of ones counted.

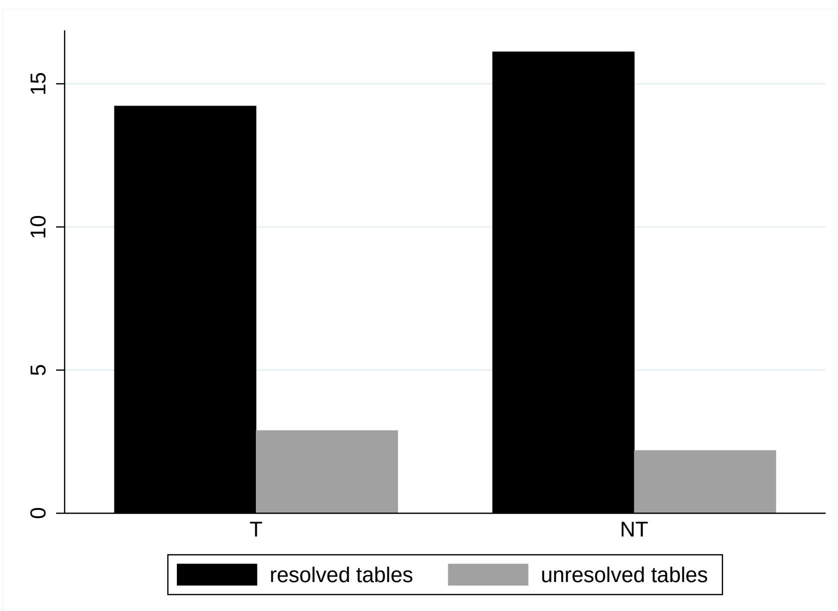


Figure 2: Average number of correctly and wrongly resolved tables in the elicitation phase

At first glance, we observe that NT subjects resolved more tables than T, however, the difference between both groups is *not* significant[18]. Whether trained or not, our subjects are

[18] $Z = -1.079$, p-value = 0.281

not different in terms of individual capacity (i.e. ability) of counting ones in tables. It will thus be possible to compare their performance in the three Stages of the experiment.

4.2.2 Performance indicator

The individual performance targets, given to the subjects in Phase II, are based on the capacity that each subject revealed in Phase I. On the basis of these targets, we determined two *individual performance indicators*. The first one, denoted $PerfIndicator_i^{acceptable}$, is the ratio between the number of revolved tables, and the individual *acceptable* target, as shown hereafter:

$$PerfIndicator_i^{acceptable} = \frac{ResolvedTables_i}{P_i^{acceptable\,target}} \quad (5)$$

The second indicator, denoted $PerfIndicator_i^{ideal}$, is the ratio between the number of revolved tables, and the individual *ideal* target, as presented hereafter[19]:

$$PerfIndicator_i^{ideal} = \frac{ResolvedTables_i}{P_i^{ideal\,target}} \quad (6)$$

In other words, the performance indicators give us the percentage of a target (acceptable or ideal) that has been achieved by the subjects. Recall that in our experiment, the period ended automatically once a subject achieved his ideal target. Hence, $PerfIndicator_i^{ideal}$ cannot be superior to 100%, contrary to $PerfIndicator_i^{acceptable}$.

Table 2 summarizes the average performance indicators of both groups of subjects, throughout the stages, where different incentives are given. It also indicates the average worst group performances throughout the stages[20]. As a reminder, Stage 1 tested an individual-based incentive (**I**), Stage 2 tested a group-based incentive *without* time constraint (**G**), and Stage 3 tested a group-based incentive *with* time constraint (**G + t.c.**), where the entire group had a given time to accomplish the individual tasks *sequentially*.

[19]Recall that $P_i^{acceptable\,target}$ is the individual's acceptable target, $P_i^{ideal\,target}$ is the individual's ideal target, and $ResolvedTables_i$ is the number of tables resolved by the individual.

[20]Recall that the worst group performance is actually the minimum $PerfIndicator_i^{acceptable}$ of a group

Table 2: Summary of average acceptable, ideal and worst group performances of T and NT when facing different incentives

Performance indicator	**I**	**G**	**G + t.c.**
	Trained to coordination (T)		
$\overline{PerfIndicator}_{acceptable}$	142.4 %	142.8 %	138.9 %
$\min_{i\in1,2,3}\left[PerfIndicator_i^{acceptable}\right]$	117 %	112.2 %	112.6 %
$\overline{PerfIndicator}_{ideal}$	90.9 %	90.9 %	88.3 %
$\min_{i\in1,2,3}\left[PerfIndicator_i^{ideal}\right]$	79.9 %	77.5 %	74.3 %
	Not trained to coordination (NT)		
$\overline{PerfIndicator}_{acceptable}$	121.9 %	131.8 %	130.5 %
$\min_{i\in1,2,3}\left[PerfIndicator_i^{acceptable}\right]$	100 %	113.7 %	110.6 %
$\overline{PerfIndicator}_{ideal}$	84.2 %	90.2 %	90.1 %
$\min_{i\in1,2,3}\left[PerfIndicator_i^{ideal}\right]$	68.7 %	79.5 %	76.3 %

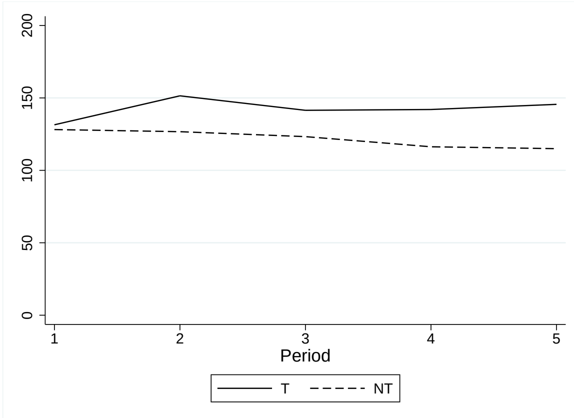
I: *Individual-based incentive*, G: *Group-based incentive*, t.c.: *time constraint.*

Observing the average performances throughout the experiment, both subject groups always perform better than their acceptable target, but never achieve their ideal target. In the remaining of the subsection, we analyze and interpret the different achieved performances summarized in Table 2.

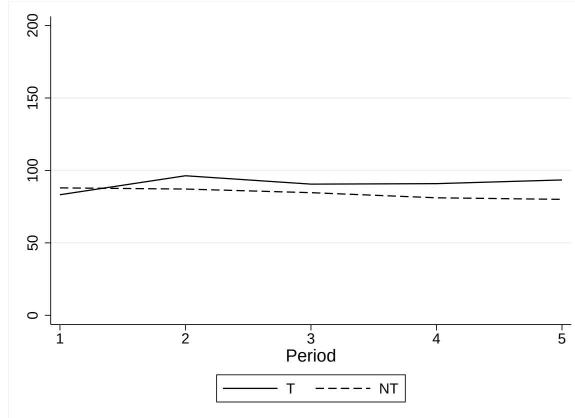
4.2.3 Individual-based incentive

The performances presented in Table 2 show that on average, T subjects, who have been trained and sensitized on efficient coordination, performed better than NT subjects when facing an individual-based incentive. Figure 3 displays the averages throughout the five periods of Stage 1, and we observe that T subjects achieve higher percentages of their targets than NT subjects in all five periods. This is true for both types of performance and the difference is statistically significant[21].

[21] $PerfIndicator_i^{acc.}$: $Z = 4.548$, p-value $= 0.000$; $PerfIndicator_i^{ideal}$: $Z = 2.011$, p-value $= 0.044$



(a) $PerfIndicator_i^{acceptable}$



(b) $PerfIndicator_i^{ideal}$

Figure 3: Evolution of subjects' average performance throughout the five periods of facing an individual-based incentive (Stage 1)

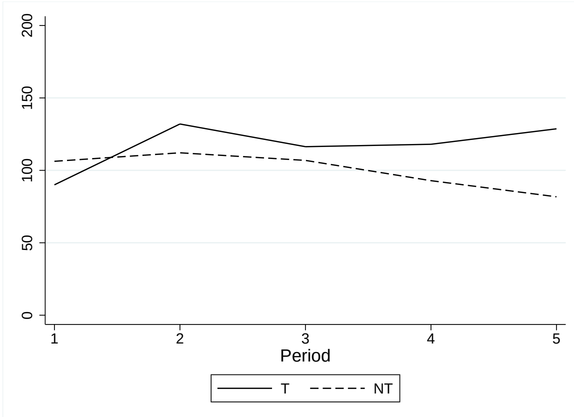
Hypothesis 1 of the paper is thus confirmed with the following result:

Result 1 *When facing an individual-based incentive, ex-ante trained subjects (T) are more efficient than the non-trained ones (NT) towards coordinating at their target levels.*

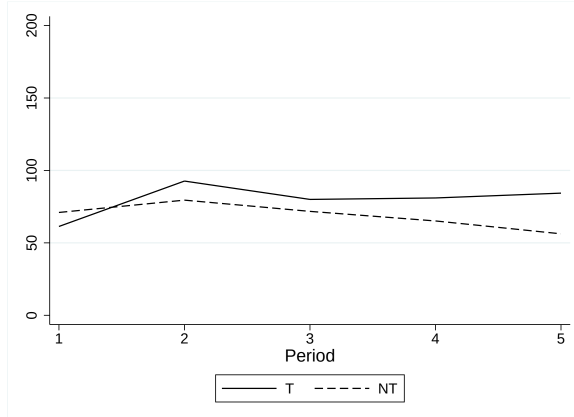
This first result seems to indicate that training about coordination may have an effect on how subjects are willing to coordinate on higher effort levels. The subjects who have been trained are significantly more efficient than the others.

This finding is also visible when observing the average worst performances of each group, on Figure 4. Apart from the first period, T subjects' worst performances are higher than those of NT subjects'. The Wilcoxon rank-sum test indeed shows us that, on average, T group subjects' worst performance are significantly higher than NT group subjects', when facing an individual-based incentive.[22] We can also see that, contrary to T, NT group subjects' worst performance has the tendency to decrease over the periods of the Stage, indicating a tiredness or a decrease in the motivation to coordinate efficiently.

[22] $WorstPerfInd._{group}^{acc.}$: $Z = 3.454$, p-value = 0.001; $WorstPerfInd._{group}^{ideal}$: $Z = 3.189$, p-value = 0.001



(a) $\min_{i \in 1,2,3} \left[PerfIndicator_i^{acceptable} \right]$



(b) $\min_{i \in 1,2,3} \left[PerfIndicator_i^{ideal} \right]$

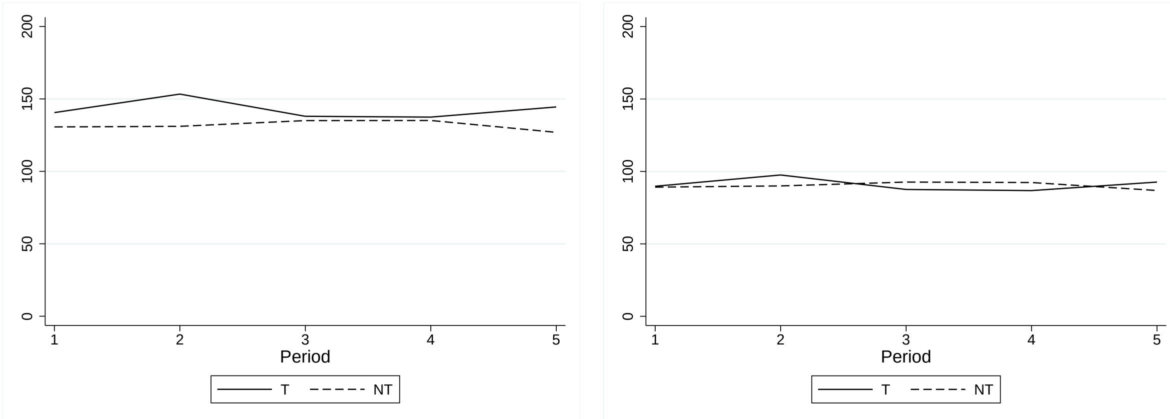
Figure 4: Evolution of the groups' average worst performance throughout the five periods of facing an individual-based incentive (Stage 1)

Let us now analyze subjects' performances when facing a group-based incentive.

4.2.4 Group-based incentive *without* time constraint

In Stage 2 of the experiment, subjects were confronted with group-based incentives, so that their payoff depended on the worst performance of all the members of a team. They still play simultaneously (i.e. *without* time constraint). This means that they were not enforced to "manage" the time given to their other team members to execute their task.

In Table 2, we do not see much difference between T and NT subjects. When observing the evolution of T subjects' coordination levels on Figure 5, we see that their average performance stays similar throughout the five periods of Stage 2. However, when comparing stages 1 and 2, we can clearly see that NT subjects' average performance increased a lot compared to when under individual-based incentive as displayed in Figure 3. This important effect on NT subjects' performance is such that both groups' coordination levels seem to end up being more or less confounded, especially with regard to the ideal target.



(a) $PerfIndicator_i^{acceptable}$ (b) $PerfIndicator_i^{ideal}$

Figure 5: Evolution of subjects' average performance throughout the five periods of facing a group-based incentive *without* time constraint (Stage 2)

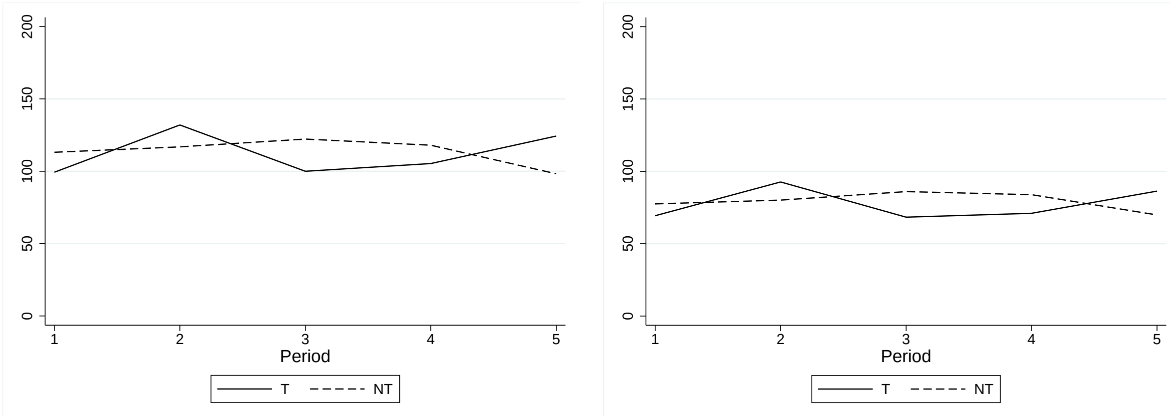
Wilcoxon rank-sum test shows that NT subjects perform better when knowing that their payoff also depends on the performance of their team members. Indeed, compared to when facing an individual-based incentive, they coordinate at significantly higher effort levels (with respect to their targets) when given a group-based incentive[23]. On the contrary, we observe that T subjects do not significantly perform better with a group-based, than with an individual-based incentive[24]. Interestingly, it seems that having been trained leads to an already high level of performance, such that the group-based incentive does not impact coordination behaviour. This leads us to the Result 2, that validates hypotheses 2 and 3:

Result 2 *When facing a group-based incentive (without time constraint), contrary to T subjects, NT subjects coordinate at more efficient performance levels than when facing an individual-based incentive.*

This result may partly be due to the increase in performance of NT subject groups' average worst performance when facing a group-based incentive, compared to when facing an individual-based incentive. We indeed find that NT subject groups' worst performance is significantly higher with the group-based incentive than with the individual-based incentive.[25] Although we observe more variation of the worst performance for T subject groups throughout the periods with the group-based incentive, than with the individual-based incentive, we find that the difference is not significant (as for the average performance of every T subject).[26]

[23] $PerfIndicator_i^{acc.}$: $Z = -2.575$, p-val = 0.010; $PerfIndicator_i^{ideal}$: $Z = -2.726$, p-value = 0.006
[24] $PerfIndicator_i^{acc.}$: $Z = 0.070$, p-value = 0.945; $PerfIndicator_i^{ideal}$: $Z = -0.263$, p-value = 0.793
[25] $WorstPerfInd._{group}^{acc.}$: $Z = -4.147$, p-value = 0.000; $WorstPerfInd._{group}^{ideal}$: $Z = -3.967$, p-value = 0.000
[26] $WorstPerfInd._{group}^{acc.}$: $Z = 1.435$, p-value = 0.151; $WorstPerfInd._{group}^{ideal}$: $Z = 1.175$, p-value = 0.240

Figure 6, hereafter, displays both subject groups' average worst performance when facing a group-based incentive *without* time constraint.



(a) $\min_{i \in 1,2,3} \left[PerfIndicator_i^{acceptable}\right]$ (b) $\min_{i \in 1,2,3} \left[PerfIndicator_i^{ideal}\right]$

Figure 6: Evolution of the groups' average worst performance throughout the five periods of facing a group-based incentive *without* time constraint (Stage 2)

Yet, regarding total performances, we observe that when facing such a group-based incentive, T subjects still significantly perform better than NT subjects, towards coordinating at their acceptable target[27], contrary to coordinating towards their ideal target[28].

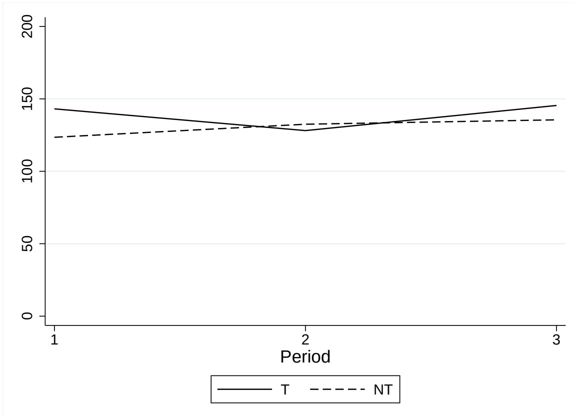
4.2.5 Group-based incentive *with* time constraint

In the last stage of the game (Stage 3), subjects were confronted with a group-based incentive with time constraint. They had a given time for their entire team, and had to play sequentially. The sequence of their respective intervention was enforced, since every of the three team members experienced all the positions (1^{st}, 2^{nd}, or 3^{rd} member to intervene) throughout the three periods of the stage. This set-up enforced the subjects playing in the first and second position to "manage" the time they allow for the next team members. Indeed, leaving the last player not enough time to coordinate at a high enough performance level, would impact the payoff of all the members.

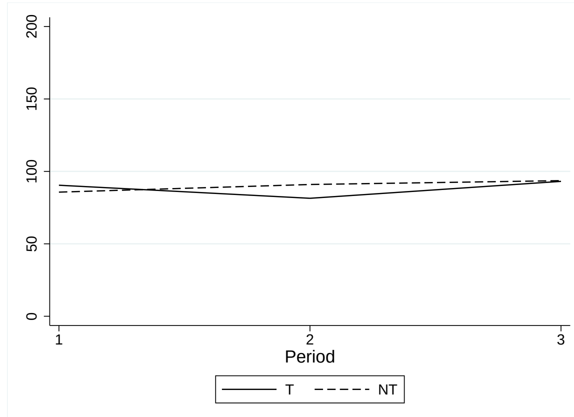
Regarding subjects' average coordination performance levels, we notice that there is no clear "domination" from one group of subjects to the other (see Table 2). As for Stage 2, we do not observe differences throughout the three periods of Stage 3 in Figure 7. The Wilcoxon rank-sum test, indeed, shows that, there is, on average, no significant difference between T and

[27] $Z = 2.531$, p-value $= 0.011$
[28] $Z = 0.328$, p-value $= 0.743$

NT subjects' coordination performance, when playing sequentially, while facing a group-based incentive[29].



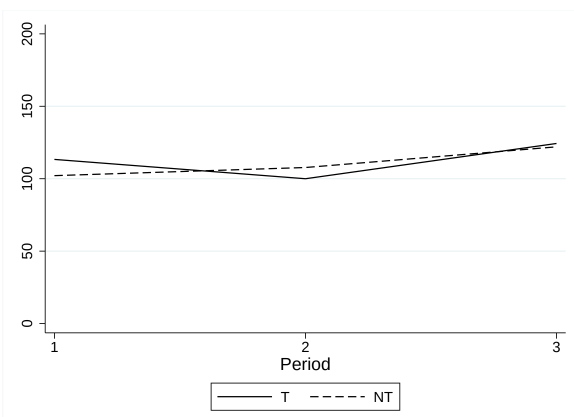
(a) $PerfIndicator_i^{acceptable}$



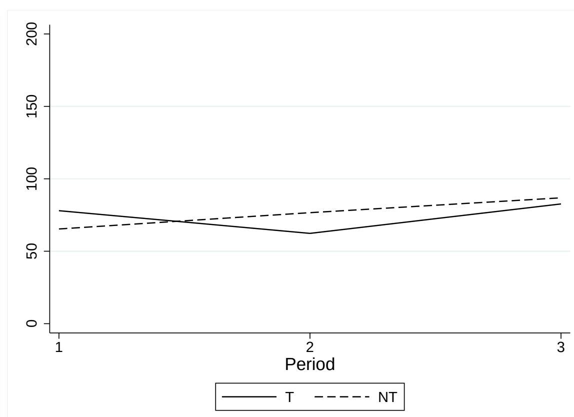
(b) $PerfIndicator_i^{ideal}$

Figure 7: Evolution of subjects' average performance throughout the three periods of facing a group-based incentive *with* time constraint (Stage 3)

The distribution of both groups' average worst performance is very similar to the total performance, as can be seen on Figure 8, hereafter. We find that there is no significant difference between T and NT group subject's average worst performance, when facing a group-based incentive *without* time constraint.[30]



(a) $PerfIndicator_i^{acceptable}$



(b) $PerfIndicator_i^{ideal}$

Figure 8: Evolution of the groups' average worst performance throughout the three periods of facing a group-based incentive *with* time constraint (Stage 3)

Although it is important to notice that these results do not take into account the sequence

[29] $PerfIndicator_i^{acc.}$: $Z = 1.368$, p-value $= 0.171$; $PerfIndicator_i^{ideal}$: $Z = -0.659$, p-value $= 0.510$
[30] $WorstPerfInd._{group}^{acc.}$: $Z = 0.232$, p-value $= 0.816$; $WorstPerfInd._{group}^{ideal}$: $Z = -0.821$, p-value $= 0.412$

order in which the subjects intervened. The sequential set-up being a notable difference with the previously one in Stage 2 (i.e. group-based incentive *without* time constraint), the order of lay may affect the performance. The average performances, given the sequence order, and with respect to subjects' acceptable and ideal targets, are summarized in Figure 9.

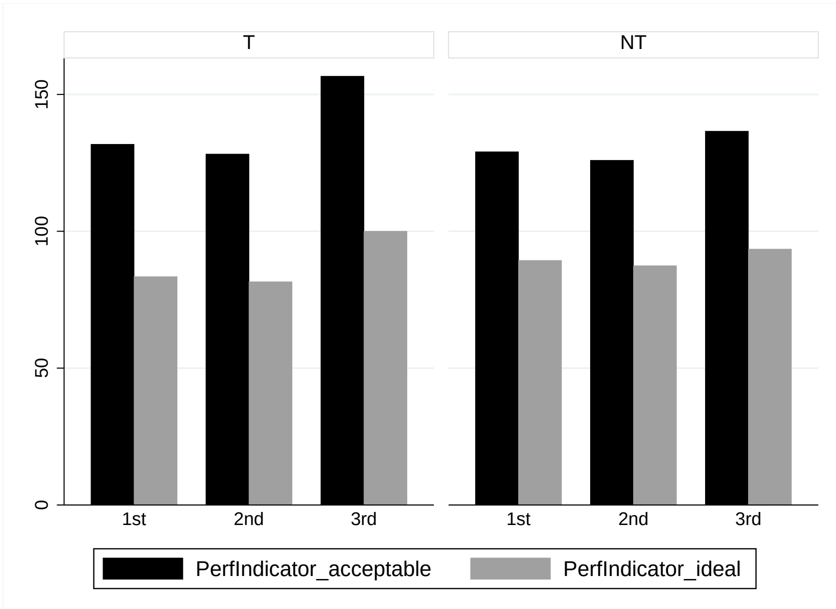


Figure 9: Subjects' average performance according to their sequence order

A first observation is that, when playing in the 3^{rd} position, T subjects achieve 100% of their ideal target. This was, on average, not the case when playing simultaneously. We indeed find that there is a significant difference of T subjects' coordination performance, towards reaching their *ideal* target[31]. This is not the case towards reaching their *acceptable* target[32], and for NT subjects, who perform significantly equally than without time constraint (i.e. Stage 2)[33].

Regarding the effect of time constraint on T subjects, we observe that, while there is no significant difference between those intervening at the first and second position[34], the last player to intervene performs significantly better than the first two players[35].

These results indicate that time constraint may affect T subjects' coordination performances. A possible mechanism may be the stress felt by T subjects intervening before the last one. As they seem to be more sensitive than NT subjects towards high and successful

[31] $PerfIndicator_i^{ideal}$: $Z = -2.157$, p-val $= 0.031$
[32] $PerfIndicator_i^{acc.}$: $Z = -1.219$, p-val $= 0.223$
[33] $PerfIndicator_i^{acc.}$: $Z = -0.810$, p-val $= 0.418$; $PerfIndicator_i^{ideal}$: $Z = -1.386$, p-val $= 0.166$
[34] $PerfIndicator_i^{acc.}$: $Z = 0.139$, p-value $= 0.889$; $PerfIndicator_i^{ideal}$: $Z = 0.226$, p-value $= 0.821$
[35] 1^{st} vs. 3^{rd}: $PerfInd_i^{acc.}$: $Z = -1.74$, p-val $= 0.082$; $PerfInd_i^{ideal}$: $Z = -2.840$, p-val $= 0.005$
2^{nd} vs. 3^{rd}: $PerfInd_i^{acc.}$: $Z = -2.011$, p-value $= 0.044$; $PerfInd_i^{ideal}$: $Z = -2.842$, p-val $= 0.005$

coordination (cf. Result 1), the possibility to *not* achieve efficient coordination causes them stress. As a response strategy, we notice that they censor themselves by voluntarily targeting a lower performance level and have the *certainty* to reach a sufficient high performance (even if lower than what they could have reached with more time), so that the last member has enough time to reach his or her acceptable target. This observation is supported by the fact that T subjects perform significantly worse (when not the last player) when facing a group-based incentive with time constraint, than when facing an individual-based incentive[36]. This brings us to a third result:

Result 3 *When playing sequentially and facing a group-based incentive, T subjects intervening before the last member are less efficient at coordinating on high effort levels than the last member. Moreover, time constraint makes them perform worse than when facing an individual-based incentive without time constraint.*

Regarding NT subjects, we find that they do not perform significantly better when being the last member to intervene, than when not.[37] Yet, when playing as the first or second member, we observe that NT subjects do *not* perform significantly better, than when facing an individual-based incentive.[38] *Without* time constraint, this was however the case (cf. Result 2). Nevertheless, they also do *not* significantly perform worse *with* than *without* time constraint.[39] Hence, in a first place, time constraint seemed to put a certain pressure on players intervening before the last one. Yet, in a second place, it becomes clear that it does not significantly alter the efficiency of giving NT subjects a group-based, instead of an individual-based incentive. Note that when considering the average performance of all the group members, we find that NT subjects perform significantly better with the group-based (*with* time constraint), than with the individual-based incentive.[40]

This brings us to a fourth result, presented hereafter:

Result 4 *Time constraint has a limited impact on NT subjects playing before the last member, so that we observe that it is more efficient (in terms of coordination) to give NT*

[36] $PerfIndicator_i^{acc.}$: $Z = 1.977$, p-value $= 0.048$; $PerfIndicator_i^{ideal}$: $Z = 2.220$, p-value $= 0.026$

[37] 1^{st} vs. 3^{rd}: $PerfInd_i^{acc.}$: $Z = -1.091$, p-val $= 0.275$; $PerfInd_i^{ideal}$: $Z = -1.132$, p-val $= 0.258$
2^{nd} vs. 3^{rd}: $PerfInd_i^{acc.}$: $Z = -1.315$, p-value $= 0.189$; $PerfInd_i^{ideal}$: $Z = -1.518$, p-val $= 0.129$

[38] $PerfIndicator_i^{acc.}$: $Z = -1.042$, p-val $= 0.297$; $PerfIndicator_i^{ideal}$: $Z = -1.348$, p-val $= 0.178$

[39] $PerfIndicator_i^{acc.}$: $Z = 1.065$, p-value $= 0.287$; $PerfIndicator_i^{ideal}$: $Z = 0.604$, p-val $= 0.546$

[40] $PerfIndicator_i^{acc.}$: $Z = -1.987$, p-val $= 0.047$; $PerfIndicator_i^{ideal}$: $Z = -2.400$, p-val $= 0.016$

subjects a group-based incentive (when playing simultaneously or sequentially), than an individual-based incentive.

To understand why the difference between the first two and the last member to play, is significant for T, let us take a look at the time subjects spent to execute their task. As the entire team was given six minutes (360 seconds) to play, every member should optimally have played two minutes (120 seconds) each. Figure 10, hereafter, displays the time spent by T and NT to execute their task, with respect to their order of intervention.

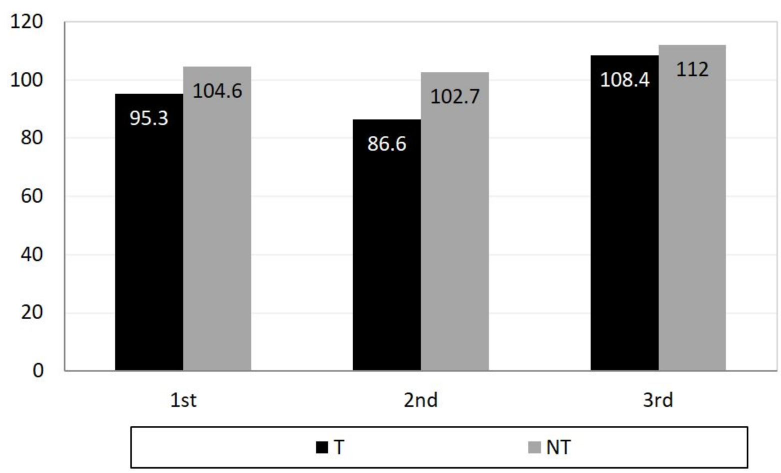


Figure 10: Average time spent for the task, given the subjects' sequence order (in seconds)

A first obvious observation, is that on average, teams did not use the entire time at their disposal. Yet, we note only a significant difference in time spent, between N and NT, when being the 2^{nd} member to play.[41] More interestingly, for T and NT respectively, there are significant differences in time spent, between all the incentive types.[42] On average, subjects needed (or used) significantly *more* time to achieve their targets with the individual-based incentive than with the group-based incentive, and this difference is even larger with the group-based incentive *with* time constraint.[43] When facing a group-based incentive, both groups also spent significantly more time *without* than *with* time constraint.[44]

By contemplating the average performances of the entire group (the last member to inter-

[41] 1^{st}: $Z = -0.849$, p-val = 0.396 ; 2^{nd}: $Z = -1.851$, p-val = 0.064 ; 3^{rd}: $Z = -0.472$, p-val = 0.637

[42] Except for T, who do not spend significantly *more* time with the individual-based, than with the group-based incentive *without* time constraint ($Z = 0.572$, p-value = 0.567)

[43] For T, individual vs. group *with* time constraint: $Z = 2.111$, p-value = 0.035
For NT, individual vs. group *without* time c.: $Z = 2.244$, p-value = 0.025 ; individual vs. group *with* time c.: $Z = 3.257$, p-value = 0.001

[44] *Without* vs. *with* time c., for T: $Z = 1.836$, p-val = 0.066 ; for NT: $Z = 1.817$, p-val = 0.069

vene, included), when playing sequentially and facing a group-based incentive, we find that T subjects do not perform significantly worse anymore than when facing an individual-based incentive[45] or a group-based incentive *without* time constraint[46]. As mentioned earlier, the inclusion of the last member's coordination performance level significantly increases the global performance of the group. However, the previous analysis on subjects' performance level when they are not the last in the sequence, shows us a decreased performance of the first and second subjects compared to *without* time constraint. Hence, when facing a group-based incentive, all the members of the group will be "punished" by receiving a lower payment. This indicates that time constraint has a twofold negative impact regarding T subjects: (1) it lowers their coordination performance level, and (2) it lowers their final payoffs.
These findings allow us to state a last result:

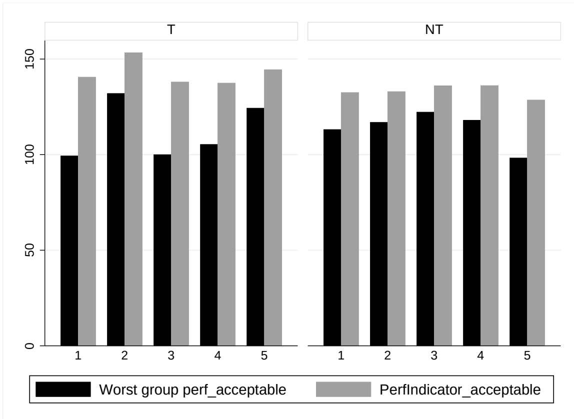
Result 5 *We observe that it is not efficient to impose time constraint on T subjects, because it "inhibits" their coordination performance, and punishes them by lowering their payments.*

Interestingly when subjects face a group-based incentive, not all the team members seem to be responsible for lowering the coordination level (and thus the payoff) of the group throughout the periods. Indeed, the worst group performance in the first period does not seem to negatively influence the other group members' in the following periods. This result is in accordance with the observations made by Bortolotti et al. (2016), but it is different to standard chosen effort experiments results where a bad performance in the beginning of a stage has been shown to spoil the performance of the whole team for the remaining periods. This phenomenon is visible in Figure 11 that shows the average performances for each period of Stages 2 and 3. Note also that there is no significant difference in the average worst group performance level, between T and NT subjects[47].

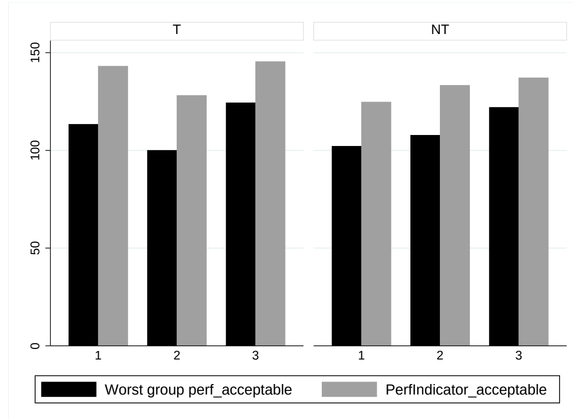
[45] $PerfIndicator_i^{acc.}$: $Z = 0.837$, p-val $= 0.4024$; $PerfIndicator_i^{ideal}$: $Z = 0.596$, p-val $= 0.552$

[46] $PerfIndicator_i^{acc.}$: $Z = 0.705$, p-val $= 0.481$; $PerfIndicator_i^{ideal}$: $Z = 0.748$, p-val $= 0.455$

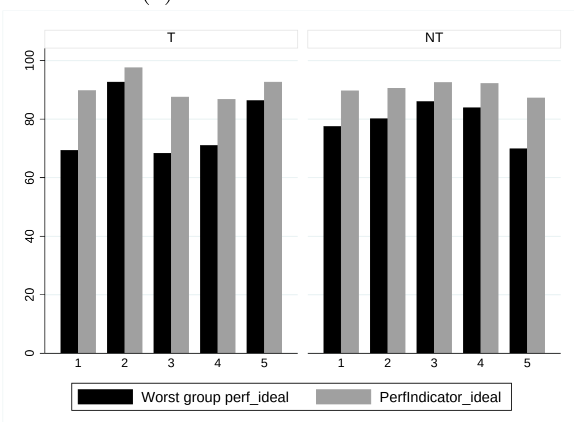
[47] $WorstPerfInd._{group}^{acc.}$: *Without* time constraint: $Z = -1.259$, p-val $= 0.208$; *with* time constraint: $Z = 0.232$, p-val $= 0.816$
$WorstPerfInd._{group}^{ideal}$: *Without* time constraint: $Z = -1.464$, p-val $= 0.143$; *with* time constraint: $Z = -0.821$, p-val $= 0.412$



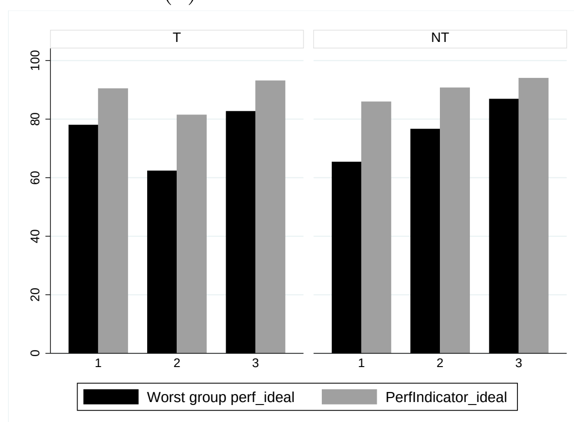
(a) *Without* time constraint



(b) *With* time constraint



(c) *Without* time constraint



(d) *With* time constraint

Figure 11: Evolution of the average worst group performances and their $PerfIndicator$ throughout the periods of facing a group-based incentive

Nevertheless, we see that on average, the worst group performance reaches at least subject's acceptable target level (see Figure 11 (a) and (b)), which indicates that they at least try to achieve their "first" target (i.e. a "good quality" work). On the contrary, the ideal target is never attained by T, nor by NT subjects (see Figure 11 (c) and (d)).

4.3 Econometric analysis

In order to verify the validity of our results, we perform an econometric analysis where we control for a series of factors. We apply a multiple linear regression analysis by running different model specifications. The econometric model for a subject i can be written as follows:

$$PerfIndicator_i^p = \alpha + \gamma Z_i + \beta_K X'_{iK} + \varepsilon_i$$

where $PerfIndicator_i^p$ with $p = (acceptable, ideal)$ are the dependent variables, α represents the intercept, γ is the estimated coefficient of the independent variable Z, β_K captures the estimated coefficient for the vector X_K which includes K exogenous control variables[48] and ε_i the error term. The tables 3, 4 and 5, hereafter, display different regressions. In Table 3, the first two specifications are concerned with Stage 1 (individual-based incentives), specifications 3 and 4 with Stage 2 (group-based incentives *without* time constraint). We compare T and NT subjects' average performances when facing those incentives. The last two columns (5 and 6) compare the individual-based and the group-based incentive *without* time constraint, for T and NT respectively.

As stated in Result 1 when facing an individual-based incentive, T subjects perform significantly better towards coordinating at their acceptable target[49], than NT subjects (column 1). Result 1 needs however to be moderated, as this difference is not significant towards reaching their ideal target[50] (column 2), contrary to the results of the non-parametric analysis.

Regarding the performance difference between T and NT, when facing a group-based incentive (*without* time constraint), we find that T subjects do *not* perform significantly better than NT subjects, regardless of the performance targeted ($PerfIndicator_i^{acc.}$[51] in column 3, and $PerfIndicator_i^{ideal}$[52] in column 4). Recall that with the non-parametric analysis, we found a significant difference between both groups, towards reaching their ideal target. This interesting new finding implies the following result:

Result 6 *When facing a group-based incentive, NT subjects "catch up" the performance levels T subjects acquired with their exogenous training, so that there is no significant difference in coordination performance between both groups.*

Now comparing both incentive types with regard to T and NT subjects respectively,

[48] The control variables included in the model specifications are the dummy variables *Age>40* (Age>40 = 1 if the subject is more than 40 years old, and 0 otherwise), *Men* (Men = 1 if the subject is a man, and 0 otherwise), and *High education* (High education = 1 if the subject has a diploma higher than high-school, and 0 otherwise).

[49] t-statistic = 2.34, p-value = 0.025

[50] t-statistic = 1.33, p-value = 0.192

[51] t-statistic = 1.28, p-value = 0.209

[52] t-statistic = 0.31, p-value = 0.757

we find that, as stated in Result 2, NT subjects perform significantly better when given a group-based, than an individual-based incentive ($PerfIndicator_i^{acc.}$[53] in column 5, and $PerfIndicator_i^{ideal}$[54] in column 6). Moreover, we see that, as before, T subjects do not perform significantly differently when facing a group-based (*without* time constraint), than when facing an individual-based incentive ($PerfIndicator_i^{acc.}$[55] in column 5, and $PerfIndicator_i^{ideal}$[56] in column 6). This confirms the fact that the exogenous training followed by NT subjects may play a role in T subjects' coordination behaviour, and that adding a group-based incentive does not lead them towards even higher coordination levels.

[53] t-statistic = 3.03, p-value = 0.005
[54] t-statistic = 3.16, p-value = 0.003
[55] t-statistic = −1.34, p-value = 0.190
[56] t-statistic = −1.45, p-value = 0.157

Table 3: Determinants of performance in I and G

	(1) PerfInd$^{acc.}$	(2) PerfInd^{ideal}	(3) PerfInd$^{acc.}$	(4) PerfInd^{ideal}	(5) PerfInd$^{acc.}$	(6) PerfInd^{ideal}
T	20.62*	6.250	12.86	1.254		
	(2.34)	(1.33)	(1.28)	(0.31)		
NT					baseline	baseline
T					21.50*	6.771
					(2.45)	(1.47)
NT - I					baseline	baseline
NT - G					9.892**	6.015**
					(3.03)	(3.16)
T - I					baseline	baseline
T - G					-9.515	-6.038
					(-1.34)	(-1.45)
Age>40	2.307	-0.501	4.006	0.331	3.157	-0.0850
	(0.35)	(-0.12)	(0.47)	(0.10)	(0.47)	(-0.03)
Men	4.193	0.813	11.07	4.856	7.631	2.835
	(0.60)	(0.12)	(0.96)	(0.98)	(1.23)	(0.67)
High education	-4.075	-2.992	0.588	-0.0873	-1.743	-1.540
	(-0.50)	(-0.69)	(0.06)	(-0.03)	(-0.21)	(-0.45)
Constant	122.2***	85.41***	128.9***	89.56***	120.6***	84.48***
	(18.60)	(18.94)	(19.28)	(23.21)	(18.84)	(19.78)
N	175	175	175	175	350	350
R^2	0.090	0.031	0.040	0.009	0.076	0.036

t statistics in parentheses

# $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(1) and (2) compare T and NT when facing an individual-based incentive (I).

(3) and (4) compare T and NT when facing a group-based incentive *without* time constraint (G).

(5) and (6) compare I and G, for T and NT respectively.

In Table 4, all the specifications are concerned with Stage 3 (G + t.c.), and more specifically, the comparison of T and NT subjects' performances, respectively, when being third to play, or not. Note that when studying T subjects' performances (cf. columns 1 and 2), we do not include control variables, because of small number of observations (27). While there exist no exact rule about the number of covariates to be included in a model, we apply the thumb rule according to Koebel et al. (2016) by using 10 observations per covariate, to prevent the problem of overfitting.

The results of the econometric analysis confirms those of the non-parametric analysis (cf.

Results 3 and 4). Namely, contrary to NT subjects ($PerfIndicator_i^{acc.}$[57] in column 3, and $PerfIndicator_i^{ideal}$[58] in column 4), the last T subjects to intervene, perform significantly better than the first two ($PerfIndicator_i^{acc.}$[59] in column 1, and $PerfIndicator_i^{ideal}$[60] in column 2).

Table 4: Determinants of performance in G+t.c.

	(1) $\text{PerfInd}^{acc.}$	(2) PerfInd^{ideal}	(3) $\text{PerfInd}^{acc.}$	(4) PerfInd^{ideal}
3^{rd} seq. order	baseline	baseline	baseline	baseline
1^{st} seq. order	-24.89*	-16.56*	-7.538	-4.154
	(-2.96)	(-3.07)	(-1.12)	(-0.98)
2^{nd} seq. order	-28.44*	-18.44*	-10.65	-6.077
	(-3.09)	(-3.25)	(-1.48)	(-1.41)
Age>40			-8.044	-8.705*
			(-1.32)	(-2.13)
High education			-2.586	-4.872
			(-0.38)	(-1.57)
Men			14.32#	7.606***
			(1.87)	(3.75)
Constant	164.0***	100.5***	138.7***	97.51***
	(13.67)	(36.39)	(20.74)	(27.48)
N	27	27	78	78
R^2	0.312	0.346	0.093	0.155

t statistics in parentheses

# $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(1) and (2) consider T subjects only, and (3) and (4) consider NT subjects only.

Furthermore, Table 5 shows specifications comparing the group-based incentive *with* time constraint, with the individual-based, and the group-based incentive *without* time constraint, for T and NT subjects respectively. Given the previous results, we, however, distinguish

[57] 3^{rd} vs. 1^{st}: t-statistic $= -1.12$, p-value $= 0.272$; 3^{rd} vs. 2^{nd}: t-statistic $= -1.48$, p-value $= 0.151$
[58] 3^{rd} vs. 1^{st}: t-statistic $= -0.98$, p-value $= 0.337$; 3^{rd} vs. 2^{nd}: t-statistic $= -1.41$, p-value $= 0.170$
[59] 3^{rd} vs. 1^{st}: t-statistic $= -2.96$, p-value $= 0.018$; 3^{rd} vs. 2^{nd}: t-statistic $= -3.09$, p-value $= 0.015$
[60] 3^{rd} vs. 1^{st}: t-statistic $= -3.07$, p-value $= 0.015$; 3^{rd} vs. 2^{nd}: t-statistic $= -3.24$, p-value $= 0.012$

between the case where subjects played only the first and the second sequence order (columns 1 and 2), and the case were all the sequence orders are considered (columns 3 and 4) in the group-based incentive *with* time constraint.

On the one hand, when considering all the sequence orders (columns 3 and 4), the econometric analysis confirms our non-parametric results (cf. Results 4 and 5). In this case, T subjects do not perform significantly worse when facing a group-based incentive *with* time constraint, than when given an individual-based[61] or a group-based incentive *without* time constraint[62] (cf. Result 5). On the contrary, NT subjects *do* coordinate at significantly higher levels when given a group-based incentive *with* time constraint, than an individual-based incentive[63] (cf. Result 4).

On the other hand, when considering only the first two sequence orders (columns 1 and 2), we can confirm the fact that NT subjects do not perform significantly better with the group-based incentive *with* time constraint, than with the individual-based incentive[64], an that they also do not perform significantly worse when facing a group-based incentive *with* time constraint, than *without* time constraint[65] (cf. Result 4). Furthermore, we see that, as stated in Result 3, T subjects perform significantly worse when given a group-based incentive *with* time constraint, than when given an individual-based incentive, towards reaching their ideal target[66]. However, Result 3 turns out to be moderated, as they do not perform significantly better towards reaching their acceptable target[67]. This result shows that time constraint especially retains T subjects to work until reaching their ideal target, and prefer to target a lower coordination level. Nevertheless, they do *not* stop before reaching at least their acceptable target. Even though they adopt a self-restricting strategy, as explained in the previous subsection, coordination at a level representing a "good" quality work, seems to remain important to them.

[61] $PerfInd._i^{acc.}$: t-statistic $= 1.42$, p-val $= 0.165$; $PerfInd._i^{ideal}$: t-statistic $= 1.64$, p-val $= 0.110$
[62] $PerfInd._i^{acc.}$: t-statistic $= 0.37$, p-val $= 0.715$; $PerfInd._i^{ideal}$: t-statistic $= 0.56$, p-val $= 0.582$
[63] $PerfInd._i^{acc.}$: t-statistic $= -2.66$, p-val $= 0.012$; $PerfInd._i^{ideal}$: t-statistic $= -2.58$, p-val $= 0.014$
[64] $PerfInd._i^{acc.}$: t-statistic $= -1.26$, p-val $= 0.215$; $PerfInd._i^{ideal}$: t-statistic $= -1.36$, p-val $= 0.181$
[65] $PerfInd._i^{acc.}$: t-statistic $= 0.77$, p-val $= 0.449$; $PerfInd._i^{ideal}$: t-statistic $= 0.52$, p-val $= 0.605$
[66] t-statistic $= 1.94$, p-val $= 0.061$
[67] t-statistic $= 1.68$, p-val $= 0.103$

Table 5: Determinants of performance in I, G and G+t.c. with respect to individual performances

	(1) $PerfInd^{acc.}$	(2) $PerfInd^{ideal}$	(3) $PerfInd^{acc.}$	(4) $PerfInd^{ideal}$
T	3.086	-6.116	9.096	-1.887
	(0.29)	(-1.25)	(0.98)	(-0.53)
NT - G+t.c	baseline	baseline	baseline	baseline
NT - I	-5.612	-4.200	-8.644*	-5.905*
	(-1.26)	(-1.36)	(-2.66)	(-2.58)
NT - G	4.281	1.815	1.249	0.110
	(0.77)	(0.52)	(0.33)	(0.05)
T - G+t.c.	baseline	baseline	baseline	baseline
T - I	17.99	12.59#	12.13	8.461
	(1.68)	(1.94)	(1.42)	(1.64)
T - G	8.475	6.551	2.618	2.423
	(0.89)	(1.12)	(0.37)	(0.56)
Age>40	-0.319	-2.406	0.318	-2.015
	(-0.05)	(-0.79)	(0.05)	(-0.68)
Man	8.793	3.518	9.331	3.834
	(1.51)	(1.00)	(1.56)	(1.15)
High education	-2.512	-2.091	-2.441	-1.987
	(-0.32)	(-0.67)	(-0.31)	(-0.66)
Constant	127.5***	89.62***	130.3***	91.11***
	(32.25)	(34.20)	(29.62)	(34.36)
N	420	420	455	455
R^2	0.069	0.043	0.068	0.038

t statistics in parentheses

# $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(1) and (2) exclude 3^{rd} order sequence in G+t.c.; (3) and (4) include it.

Finally, in Table 6, all the specifications compare both groups' worst performances, when facing different incentives. More specifically, regressions (1) and (2) compare both group-based incentives with the individual-based incentive, for T and NT subjects, and (3) and (4) compare the group-based incentive *with* time constraint, with the individual-based and the group-based incentive *without* time constraint, for T and NT subjects.

The econometric analysis confirms the results given in the non-parametric analysis. We indeed see that NT subject groups' worst performance levels are significantly higher when facing group-based incentives (*without* and *with* time constraint), than when facing an individual-based incentive (columns 1 and 2). For T subject groups, we find the opposite result. Their worst performance levels are significantly lower then facing a group-based incentive, than when facing an individual-based incentive (columns 1 and 2). Finally, we also see in Table 6 that neither T nor NT subject groups' worst performances significantly vary between both group-based incentives (columns 3 and 4).[68] These findings indicate that they may be due to the fact that the worst performances of the groups (and not only the best group performances) vary a lot given what type of incentive subjects are facing. This brings us to a last result:

Result 7 *Incentive types impact the worst group performance levels, so that this latter one is lower with group-based than with individual-based incentives, for T subjects, and higher with group-based than with individual-based incentives, for NT subjects.*

This result is interesting and important when being confronted to a weak-link production type. Indeed, when the final outcome (and not only the payoff) of a teamwork depends on the lowest performance of the team, the most important output is precisely this worst performance level. Result 7 may thus be important to consider when proposing an appropriate contract in the context of a weak-link environment, as for example a low energy renovation or construction work.

[68]This was not the case for T subject groups, according to the non-parametric analysis.

Table 6: Determinants of performance in I, G and G+t.c. with respect to worst group performances

	(1) $\text{WorstPerf}^{acc.}_{group}$	(2) $\text{WorstPerf}^{ideal}_{group}$	(3) $\text{WorstPerf}^{acc.}_{group}$	(4) $\text{WorstPerf}^{ideal}_{group}$
NT	baseline	baseline	baseline	baseline
T	18.21*	11.58*	3.117	-1.516
	(2.69)	(2.72)	(0.58)	(-0.38)
NT - I	baseline	baseline	-10.65***	-7.567**
			(-3.65)	(-3.51)
NT - G	13.73***	10.75***	3.075	3.183
	(4.02)	(3.77)	(0.84)	(1.07)
NT - G+t.c.	10.65***	7.567**	baseline	baseline
	(3.65)	(3.51)		
T - I	baseline	baseline	15.09*	13.10*
			(2.67)	(2.71)
T - G	-18.53**	-13.08**	-3.431	0.017
	(-3.33)	(-2.85)	(-0.78)	(0.00)
T - G+t.c.	-15.09*	-13.10*	base line	base line
	(-2.67)	(-2.71)		
Age>40	8.024*	-0.160	8.024*	-0.160
	(2.04)	(-0.04)	(2.04)	(-0.04)
Men	10.40#	8.182#	10.40#	8.182#
	(1.83)	(1.85)	(1.83)	(1.85)
High education	-9.044	-5.065	-9.044	-5.065
	(-1.44)	(-1.17)	(-1.44)	(-1.17)
Constant	99.02***	69.44***	109.7***	77.01***
	(19.89)	(17.40)	(31.41)	(23.48)
N	429	429	429	429
R^2	0.097	0.069	0.097	0.069

t statistics in parentheses

# $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(1) and (2) compare group-based incentives with the individual-based incentive, for T and NT subjects.

(3) and (4) compare the group-based incentive *with* time constraint, with the individual-based and the group-based incentive *without* time constraint, for T and NT subjects.

5 Discussion and concluding remarks

In this paper, we presented an experiment where subjects played a real-effort weak-link game. The aim of the study was to analyse the coordination capacity of *ex-ante* trained and non trained (to coordination) craftsmen, when facing individual-based and a group-based incentives *without* and *with* time constraint (with weak-link payment). A particularity of the experiment, is the introduction of individual performance targets (a minimum acceptable, and a maximum ideal target) subjects had to achieve.

Our results suggest that trained subjects coordinate at significantly higher effort levels than non-trained subjects, when facing an individual-based incentive. However, when facing a group-based incentive, non-trained subjects appear to "catch up" trained subjects in terms of coordination level, while these latter subjects do not significantly increase their performance level compared to when given an individual-based incentive. This suggests that proposing a group-based incentive to subjects who have previously been trained on coordination, does not yield higher overall coordination levels. Indeed, their enhanced sensitivity to successful and efficient coordination (that is, their optimist beliefs about coordination) seems to be a sufficiently strong mechanism to incentivize towards coordinating at high effort levels. This corroborates the findings of Cooper et al. (2018), who suggest that assigning a high performance pay to "optimists", increases the probability of high and successful coordination. The fact that, in our experiment, trained subjects were aware about their team members' same training, reinforced their trust in the coordination capacity of the other members, and may explain the realization of this result. Yet, an unexpected result when enforcing the subjects a sequential game (with a group-based incentive) with a given amount of time for the entire group (i.e. time constraint), is that, contrary to non trained subjects, trained subjects playing before the last one in the group, perform significantly worse than the last player. By adopting a self-restricting strategy, they would perform significantly worse than when facing an individual-based incentive. As the possibility to *not* achieve efficient coordination causes them stress, trained subjects voluntarily target lower performance levels (than their real ability), to have the certainty to reach a sufficiently high performance, so that the last member in the sequence order has enough time to reach his or her acceptable target. Such a strong (and negative) effect of time constraint is not visible on the coordination behaviour of non trained subjects. Indeed, they perform significantly better with a group-based than with an individual-based incentive, whether they have to play simultaneously or sequentially.

In hand of the results presented in this section, imposing a time constraint when subjects have to intervene sequentially (i.e. attributing delay penalties to the entire team when coordination on high performance levels has failed in a given time), does not seem to be an efficient solution to incentivize towards successful coordination. This is particularly the case for subjects having participated in a training on coordination. However, training courses on coordination, although time demanding and expensive,is a very efficient alternative measure to group-based incentives. Though this latter incentive is very efficient to increase performance of subjects who have never participated in a training course on coordination. Group contracts may thus be a good solution, cheaper (with regard to time and money) than a training, to incentivize towards efficient coordination.. However, when working in an environment presenting the weak-link property, our results indicate that it may be more efficient to assign group-based incentives (*with* or *without* time constraint) to non trained subjects, and individual-based incentives to trained subjects. This result is in contradiction with the one presented by Bortolotti et al. (2016), who find that group-based incentives are as effective as individual-based incentives. Considering non trained subjects (as it is the case in other studies), we observe that worst performance is significantly lower with individual-based than with group-based incentives.

The small number of trained subjects having participated to the experiment (9) compared to the number of non trained subjects (27), constitutes the main limitation of the present study. The reason for this small number, is the difficulty to mobilize them simultaneously in a given location, as only around 200 craftsmen were trained through this particular training course (Dorémi), in the entire Grand Est Region, in northeastern of France. It would however be interesting to conduct a further session with trained subjects, to increase the possibility of external validation of the results.

In a further version of this experiment it would also be interesting to add a stage, where subjects would *not* be paid beyond their acceptable target. This would allow us to determine if subjects actually took into account the fact that they were assigned two distinct targets, and not only an ideal one, in their coordination behaviour.

APPENDIX

A Instructions of the experiment in French

Informations générales

Nous vous remercions de participer à cette expérience sur la prise de décision. Dans cette expérience, vos gains dépendent de vos décisions et de celles d'autres participants. Nous vous demandons donc de lire attentivement ces instructions, elles doivent vous permettre de bien comprendre l'expérience. Toutes vos décisions sont anonymes. Vous n'entrerez jamais votre nom sur l'ordinateur. Vous indiquerez vos choix à la tablette devant laquelle vous êtes assis(e).

À partir de maintenant nous vous demandons de ne plus parler. Si vous avez une question levez la main et un expérimentateur viendra vous répondre en privé. Il est formellement interdit de communiquer avec un autre participant pendant l'expérience. Si vous ne respectez pas cette règle vous serez exclu de l'expérience et de tout paiement éventuel.

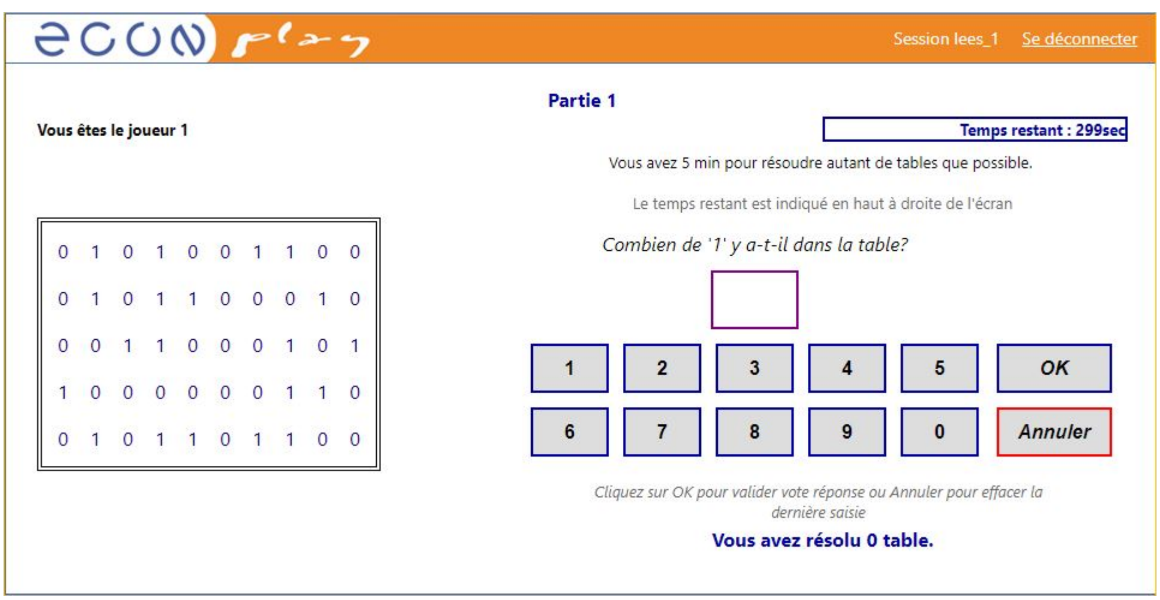
Tout au long de l'expérience, vous ferez partie d'un groupe composé de 3 joueurs choisis aléatoirement par l'ordinateur : vous et 2 autres joueurs participant à l'expérience. Vous ne pouvez pas connaitre l'identité des autres membres de votre groupe, de même qu'aucun membre de votre groupe ne peut connaitre votre identité. Vous ne connaissez pas non plus la constitution des autres groupes. Votre groupe restera identique tout au long de l'expérience.

L'expérience sera subdivisée en 4 parties. Les instructions spécifiques à chaque partie vous seront transmises avant celle-ci. Dans chaque partie, vous pourrez accumuler des gains exprimés en ECU (devise propre au jeu). à la fin de l'expérience vos gains totaux en ECU accumulés au cours des 4 parties seront convertis en euros au taux suivant : $100ECU = 1$ euro.

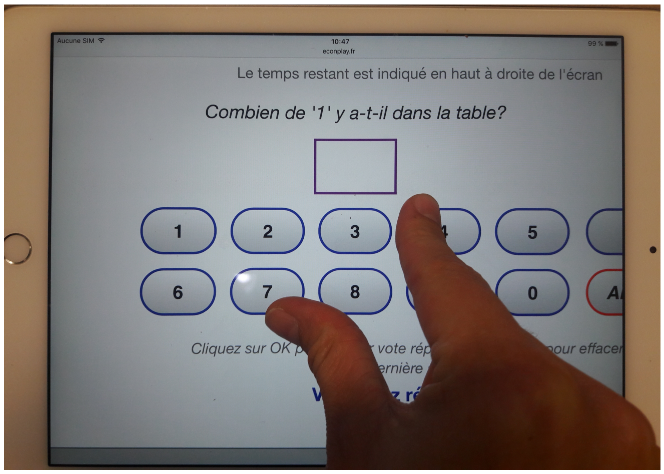
Les gains en euros que vous aurez réalisés vous seront alors versés en liquide.

Instructions de la Partie 1

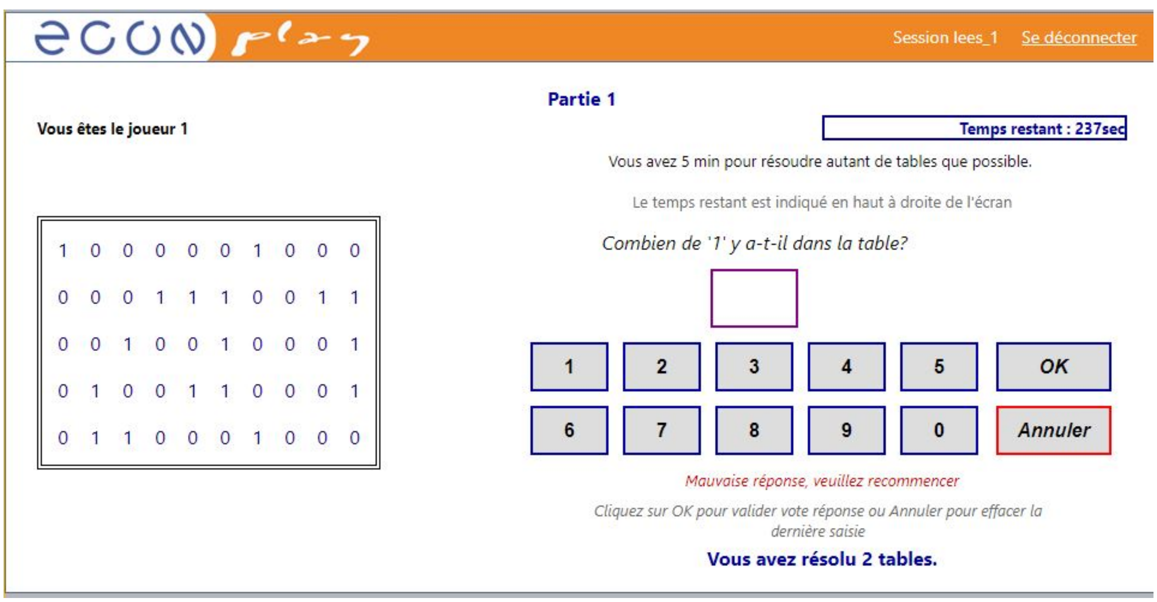
Lors de la Partie 1, votre tâche consiste à compter le nombre de '1' présents dans une table composée de '0' et '1'. Vous avez 5 minutes, soit 300 secondes, pour résoudre le plus de tables possibles. Le jeu se présente de la manière suivante :



Sur l'écran est présent une table composée de '0' et '1' et vous devez entrer, à l'aide des touches numériques, le nombre de '1' dans la fenêtre de réponse située à droite. Vous n'avez pas besoin d'appuyer sur la case vide avant de taper les chiffres : la saisie se fera directement à l'aide des touches numériques. Pour valider votre réponse, il faut appuyer sur « OK ». Si vous voulez modifier votre réponse, il faut appuyer sur « Annuler », puis retaper votre réponse à l'aide des touches numériques. Le temps restant est affiché sous forme de compte à rebours en secondes en haut à droite de l'écran. Si vous voyez qu'en cliquant 2 fois de suite sur l'écran, vous avez zoomé, vous pouvez à tout moment dé-zoomer en faisant glisser 2 doigts dans un mouvement de pincement sur l'écran, comme indiqué sur la photo suivante :



Si vous validez un résultat incorrect, un message d'erreur apparaîtra comme indiqué sur la capture d'écran suivante :



Vous aurez alors 2 nouvelles chances pour donner la bonne réponse. Si vous vous trompez 3 fois, un nouveau tableau sera généré. En bas à droite, le nombre de tables résolues est affiché. Notez que vous ne serez pas pénalisé si vous vous trompez. Seul le nombre de tables résolues sera pris en compte.

Gardez en tête que le compte à rebours des 5 minutes démarre dès que la première table est affichée.

à la fin de la période de 5 minutes, un écran affichera le nombre de tables que vous avez correctement résolues, ainsi que votre gain pour cette période.

Vous toucherez 10 ECU par table résolue. Si vous avez par exemple compté correctement 5 tables, votre gain sera de 50 ECU :

$$Gain\ P1 = 5 \cdot 10 = 50\ ECU$$

Les gains de cette Partie vous seront payés à la fin de l'expérience.

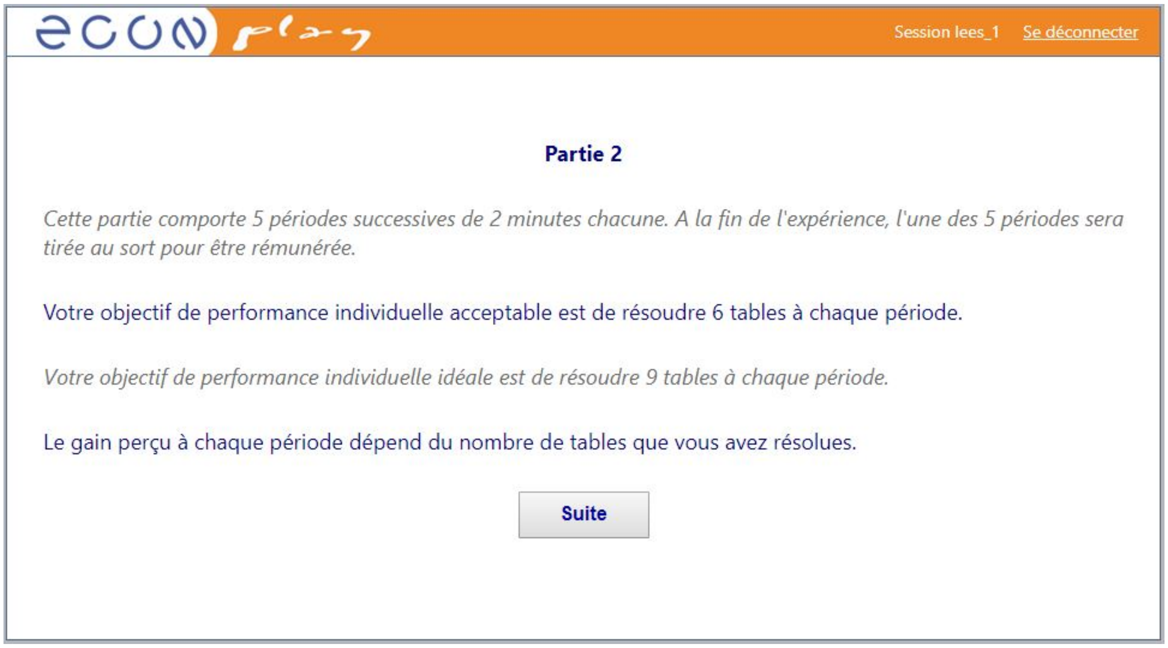
Avant de commencer la Partie 1, vous aurez une phase d'entraînement de 2 minutes, pour vous familiariser avec le jeu et le fonctionnement de la tablette. Cette phase ne sera pas rémunérée.

Instructions de la Partie 2

Dans la Partie 2, votre tâche consiste à nouveau à compter le nombre de '1' présents dans des tables composées de '0' et '1'. Vous faites toujours partie du même groupe de 3 personnes. La Partie 2 est divisée en 5 périodes de 2 minutes, soit 120 secondes, chacune. Contrairement à la Partie 1, vos gains dépendent de la réalisation des objectifs qui vous sont assignés. En effet, deux objectifs vous seront donnés:

1. Un objectif de performance individuelle ACCEPTABLE
2. Un objectif de performance individuelle IDEALE

Pour comprendre la différence entre ces deux objectifs, voyons un exemple concret. Imaginez un menuisier sur un chantier de rénovation. L'objectif acceptable représente le fait que le menuisier ait correctement posé la nouvelle fenêtre. L'objectif idéal représente le fait que le menuisier ait posé sa fenêtre de telle sorte à ce qu'elle puisse permettre d'atteindre le niveau d'étanchéité à l'air minimum requis pour atteindre un niveau BBC (Bâtiment Basse Consommation). En pratique, il faut au minimum atteindre votre objectif acceptable, mais atteindre votre objectif idéal vous permet de contribuer à l'atteinte du niveau BBC. L'objectif acceptable sera donc toujours inférieur à l'objectif idéal. Vos objectifs à atteindre vous seront communiqués au début de la Partie 2, comme affiché ci-dessous. Vos objectifs peuvent être différents que sur cette capture d'écran.



Vos gains lors de chaque période de 2 minutes sont déterminés par votre performance individuelle et sont calculés de la manière suivante :

$$Gain\ P2 = 100 + 800 \cdot \frac{tables\ résolues}{objectif\ de\ performance\ ind.\ ACCEPTABLE}$$

Prenons un exemple dans lequel on vous demande de résoudre 4 tables pour atteindre votre objectif acceptable, et de résoudre 6 tables pour atteindre votre objectif idéal. Si vous résolvez 3 tables pendant la période de jeu, vous avez atteint $\frac{3}{4}$ (soit 75%) de votre objectif acceptable et votre gain pour cette période est

$$Gain\ P2 = 100 + 800 \cdot \left(\frac{3}{4}\right) = 700\ ECU$$

Si au contraire, vous résolvez 4 tables, vous avez rempli 100% votre objectif acceptable et votre gain est

$$Gain\ P2 = 100 + 800 \cdot \left(\frac{4}{4}\right) = 900\ ECU$$

De même, si vous résolvez 5 tables (soit 125% de votre objectif acceptable) votre gain est

$$Gain\ P2 = 100 + 800 \cdot \left(\frac{5}{4}\right) = 1100\ ECU$$

La réalisation de votre objectif idéal n'intervient pas dans vos gains. Cependant, si vous aviez, toujours dans le même exemple, réussi à résoudre 6 tables (soit 150% de votre objectif acceptable), vous avez rempli vos deux objectifs, acceptable et idéal, et votre gain pour cette période est

$$Gain\ P2 = 100 + 800 \cdot \left(\frac{6}{4}\right) = 1300\ ECU$$

Dans le jeu, vous ne pouvez pas aller au-delà de votre objectif idéal. Lorsque vous atteignez le nombre de tables résolues qui correspond à cet objectif, la période de jeu s'achève, et les résultats sont affichés.

Une page vous affichera les informations suivantes :

1. Le nombre de tables à résoudre pour atteindre votre objectif acceptable ;
2. Le nombre de tables à résoudre pour atteindre votre objectif idéal ;
3. Le nombre de tables que vous avez résolues lors de la période de jeu ;
4. Le pourcentage de tables résolues par rapport à votre objectif acceptable ;
5. Le pourcentage de tables résolues par rapport à votre objectif idéal ;
6. Votre gain pour cette période (en ECU).

Le gain que vous remporterez pour la Partie 2 sera tiré au sort parmi les 5 périodes de jeu que vous allez jouer. Vous ne remportez donc le gain que d'une seule période sur 5 jouées.

Instructions de la Partie 3

La Partie 3 est similaire à la Partie 2 que vous venez de jouer. Vous jouerez toujours 5 périodes de 2 minutes chacune. Cependant, vos gains pour chaque période seront calculés différemment qu'à la Partie 2.

Lors de la Partie 2, vos gains dépendaient uniquement de votre performance individuelle lors de chaque période de jeu. Dans la Partie 3, vos gains dépendent aussi de la performance individuelle des autres membres de votre groupe. Plus précisément, ils dépendent de la performance individuelle du membre du groupe qui a fait la plus faible performance par rapport à son objectif de performance individuelle acceptable. Les gains des trois membres du groupe sont identiques et sont calculés comme ceci :

$$Gain\ P3 = 100 + 800 \cdot (plus\ faible\ atteinte\ de\ l'obj.\ acceptable\ au\ sein\ du\ groupe)$$

Prenons un exemple. Vous avez atteint votre objectif acceptable, soit 100%, le 2nd membre du groupe a atteint 125% de son objectif acceptable, et le 3ème membre du groupe a atteint 75% de son objectif acceptable. Le gain de chacun des membres de votre groupe sera le même:

$$Gain\ P3 = 100 + 800 \cdot 75\% = 700\ ECU$$

Si au contraire, vous avez atteint 50% de votre objectif acceptable, le 2nd membre du groupe a atteint 140% de son objectif acceptable, et le 3ème membre du groupe a atteint 90% de son objectif acceptable, le gain de chacun des membres de votre groupe sera le suivant:

$$Gain\ P3 = 100 + 800 \cdot 50\% = 500\ ECU$$

Le gain que vous remporterez pour la Partie 3 sera tiré au sort parmi les 5 périodes de jeu que vous allez jouer. Vous ne remportez donc le gain que d'une seule période sur 5 jouées.

Instructions de la Partie 4

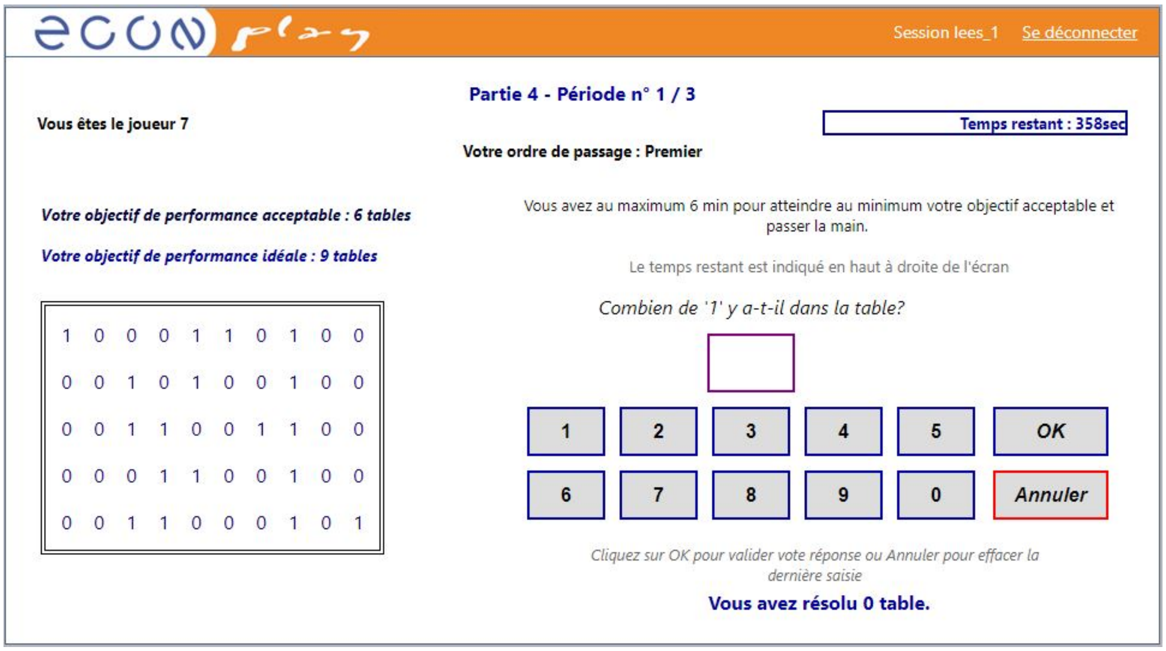
Vos gains à la Partie 4 seront calculés de la même manière qu'à la Partie 3. Le jeu sera le même que dans toutes les parties précédentes.

Le changement à la Partie 4 est que vous allez effectuer votre tâche chacun à votre tour au sein du groupe dont vous faites partie. Plus précisément, le jeu consistera en 3 périodes de 6 minutes, soit 360 secondes, chacune.

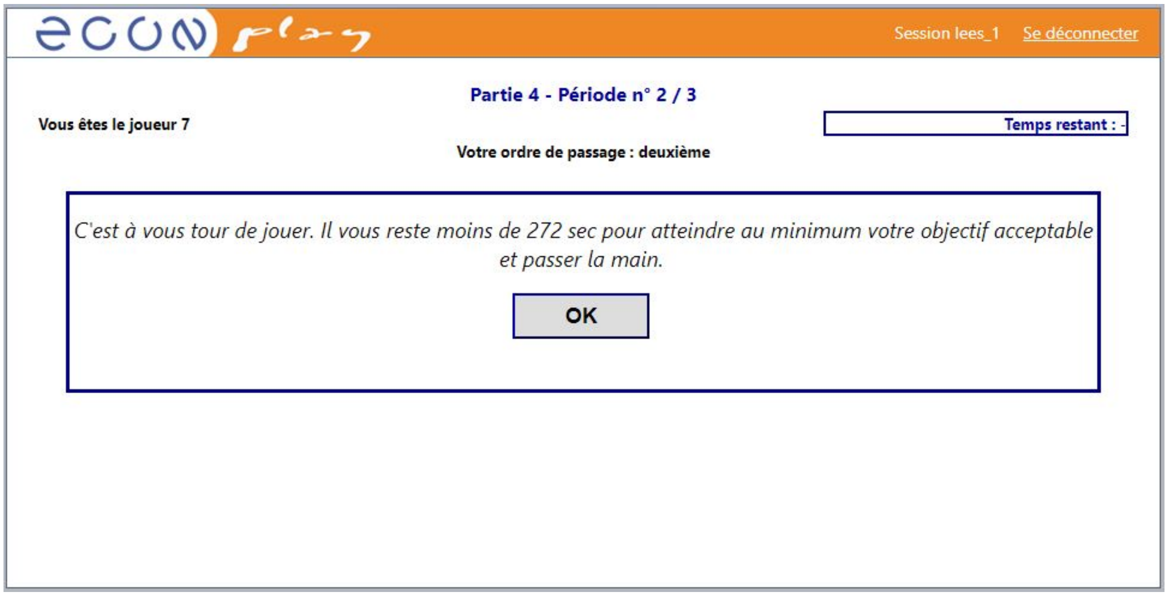
Au cours de chaque période, un des membres du groupe commencera en premier et aura comme auparavant l'objectif d'atteindre au moins son objectif acceptable. Il pourra alors continuer pour essayer d'atteindre son objectif idéal.

Dès qu'il atteint son objectif acceptable, il peut passer la main au joueur suivant. Par contre, s'il le souhaite, il peut continuer jusqu'à atteindre son objectif idéal puis passer la main automatiquement au joueur suivant.

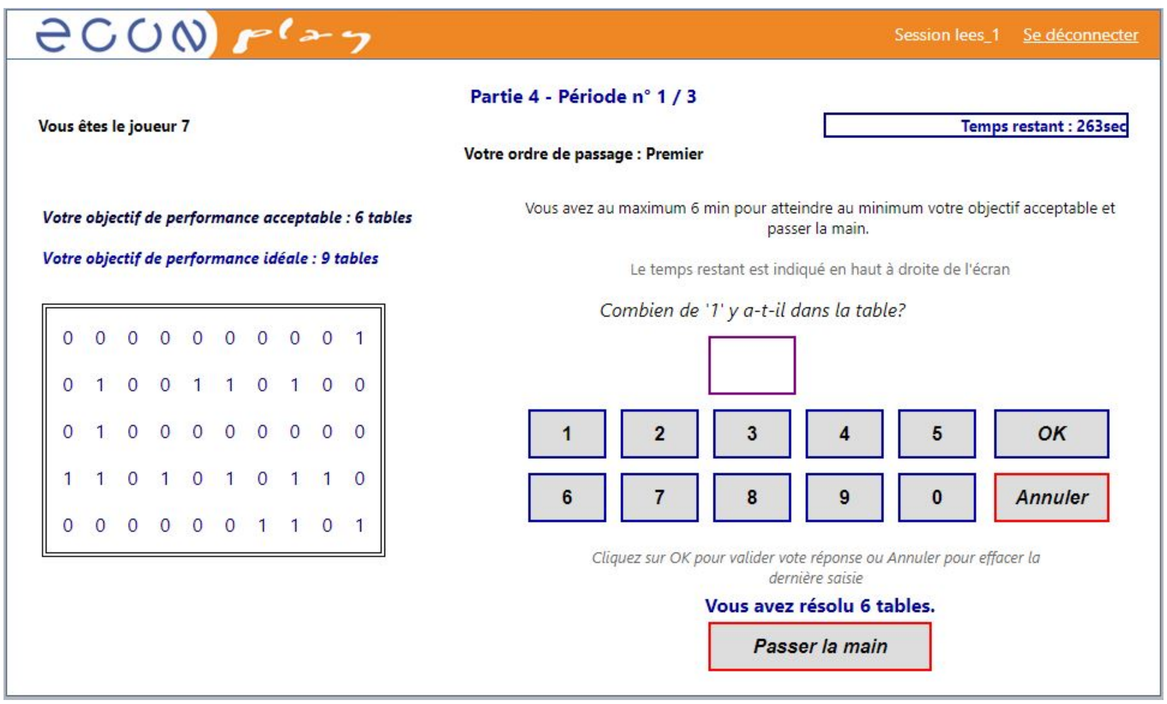
Les 360 secondes disponibles dans cette période sont pour l'ensemble du groupe. Le nombre de secondes utilisées par un joueur ne sont plus disponibles pour les suivants. Le temps restant sur le total des 360 secondes est affiché en haut à droite. Au moment de jouer, votre ordre de passage pour la période vous est indiqué sur l'écran. Votre ordre de passage est déterminé aléatoirement. Si vous êtes le 1er joueur à jouer, le jeu démarrera immédiatement comme indiqué sur la capture d'écran suivante :



Si vous êtes le $2^{ème}$ ou le $3^{ème}$ à jouer, le temps restant à jouer vous sera précisé sur un écran à part avant de commencer à jouer. Sur la capture d'écran suivante par exemple, l'ordre de passage du joueur 7 est $2^{ème}$ à la période 2 sur 3. Il lui reste 272 secondes à jouer à partir du moment où il appuie sur « OK ». Cela signifie que le 1^{er} membre du groupe a déjà joué pendant $(360 - 272 =)$ 88 secondes avant lui.



Si vous êtes le 1^{er} ou le $2^{ème}$ joueur dans l'ordre de passage, dès que vous atteignez votre objectif acceptable, un bouton « Passer la main » apparait en bas à droite de l'écran comme indiqué sur la capture d'écran suivante :



Vous avez alors le choix soit de passer la main au prochain joueur pour qu'il puisse commencer à jouer, soit de continuer à jouer jusqu'à au plus votre objectif idéal. Si vous décidez de continuer, vous pourrez quand même passer la main à tout moment.

Gardez en tête que vos gains sont calculés comme à la Partie 3 et dépendent de la plus faible performance individuelle du groupe. Il est donc important de laisser suffisamment de temps aux joueurs qui vont jouer après vous.

Prenons un exemple. Vous atteignez 100% de votre objectif acceptable en 125 secondes et vous décidez de passer la main au prochain joueur. Puis, le second joueur atteint son objectif acceptable mais décide de continuer à jouer. Il décide de passer la main lorsqu'il a atteint 110% de son objectif acceptable, après 200 secondes de jeu. Il reste alors $(360-125-200=)35$ secondes au dernier joueur pour jouer. Il atteint alors 40% de son objectif acceptable avec les 35 secondes restantes. La plus faible performance individuelle du groupe est donc de 40%. Le gain de chaque joueur est alors de

$$Gain\ P4 = 100 + 800 \cdot 40\% = 420\ ECU$$

Le gain que vous remporterez pour la Partie 4 sera tiré au sort parmi les 3 périodes de jeu que vous allez jouer. Vous ne remportez donc le gain que d'une seule période sur 3 jouées.

References

Abeler, J., A. Falk, L. Goette, and D. Huffman (2011). Reference Points and Effort Provision. *The American Economic Review VO - 101* (2), 470.

Barrett, S. (2016). Coordination vs. voluntarism and enforcement in sustaining international environmental cooperation. *Proceedings of the National Academy of Sciences 113* (51), 14515 LP – 14522.

Berninghaus, S. K. and K.-M. Ehrhart (2001). Coordination and information: recent experimental evidence. *Economics Letters 73*, 345–351.

Blume, A. and A. Ortmann (2007). The Effects of Costless Pre-Play Communication: Experimental Evidence from Games with Pareto-ranked Equilibria. *Journal of Economic Theory 132*, 274–290.

Bornstein, G., U. Gneezy, and R. Nagel (2002). The effect of intergroup competition on group coordination: an experimental study. *Games and Economic Behavior 41* (1), 1–25.

Bortolotti, S., G. Devetag, and A. Ortmann (2016). Group incentives or individual incentives? A real-effort weak-link experiment. *Journal of Economic Psychology 56* (C), 60–73.

Brandts, J. and D. J. Cooper (2006). A Change Would Do You Good .... An Experimental Study on How to Overcome Coordination Failure in Organizations. *The American Economic Review 96* (3), 669–693.

Brandts, J. and D. J. Cooper (2007). It's What You Say, Not What You Pay: An Experimental Study of Manager-Employee Relationships in Overcoming Coordination Failure. *Journal of the European Economic Association 5* (6), 1223–1268.

Brandts, J., D. J. Cooper, and E. Fatas (2007). Leadership and overcoming coordination failure with asymmetric costs. *Experimental Economics 10* (3), 269–284.

Carpenter, J., S. Bowles, H. Gintis, and S.-H. Hwang (2009). Strong reciprocity and team production: Theory and evidence. *Journal of Economic Behavior and Organization 71*, 221–232.

Chaudhuri, A., A. Schotter, and B. Sopher (2009). Talking Ourselves to Efficiency: Coordination in Inter-Generational Minimum Effort Games with Private, Almost Common and Common Knowledge of Advice. *The Economic Journal 119* (534), 91–122.

Chen, R. (2017). Coordination with endogenous groups. *Journal of Economic Behavior & Organization 141*, 177–187.

Chen, Y., S. X. Li, T. X. Liu, and M. Shih (2014). Which hat to wear? Impact of natural identities on coordination and cooperation. *Games and Economic Behavior 84*, 58–86.

Cooper, D. J., C. A. Ioannou, and S. Qi (2018). Endogenous incentive contracts and efficient coordination. *Games and Economic Behavior 112*, 78–97.

Cooper, R., D. DeJong, R. Forsythe, and T. Ross (1992). Communication in Coordination Games. *The Quarterly Journal of Economics 107* (2), 739–771.

Corgnet, B., R. Hernan-Gonzalez, and S. Rassenti (2015). Peer Pressure and Moral Hazard in Teams: Experimental Evidence. *Review of Behavioral Economics 2* (4), 379–403.

Cosaert, S., M. Lefebvre, and L. Martin (2019). Earnings and work time targets in effort provision tasks: a revealed preference analysis. *Mimeo*.

Dai, Z., R. M. Hogarth, and M. C. Villeval (2015). Ambiguity on audits and cooperation in a public goods game. *European Economic Review 74*, 146–162.

Engelmann, D. and H.-T. Normann (2010). Maximum effort in the minimum-effort game. *Experimental Economics 13*(3), 249–259.

Falk, A. and A. Ichino (2006). Clean Evidence on Peer Effects. *Journal of Labor Economics 24*(1), 39–57.

Holmstrom, B. (1982). Moral Hazard in Teams. *The Bell Journal of Economics* (2), 324—-.

Kandel, E. and E. P. Lazear (1992). Peer Pressure and Partnerships. *Journal of Political Economy 100*(4), 801.

Knez, M. and D. Simester (2001). Firm Wide Incentives and Mutual Monitoring at Continental Airlines. *Journal of Labor Economics 19*(4), 743–772.

Koebel, B., A. Schmitt, and S. Spaeter (2016). Do Self-Theories on Intelligence Explain Overconfidence and Risk Taking? A Field Experiment.

Marchegiani, L., T. Reggiani, and M. Rizzolli (2016). Loss averse agents and lenient supervisors in performance appraisal. *Journal of Economic Behavior & Organization 131*, 183–197.

Meidinger, C., J.-L. Rullière, and M.-C. Villeval (2003). Does Team-Based Compensation Give Rise to Problems When Agents Vary in Their Ability? *Experimental Economics 6*(3), 253–272.

Riedl, A., I. M. T. Rohde, and M. Strobel (2016). Efficient Coordination in Weakest-Link Games. *The Review of Economic Studies 83*(2), 737–767.

Van Huyck, J. B., R. C. Battalio, and R. O. Beil (1990). Tacit Coordination Games, Strategic Uncertainty, and Coordination Failure. *The American Economic Review 80*(1), 234–248.

Vranceanu, R., F. El Ouardighi, and D. Dubart (2015). Team Production with Punishment Option: Insights from a Real-Effort Experiment. *Managerial and Decision Economics 36*, 408–420.

Weber, R., C. Camerer, Y. Rottenstreich, and M. Knez (2001). The Illusion of Leadership: Misattribution of Cause in Coordination Games. *Organization Science 12*(5), 582.