Group vs. Individual Decision-making in Social- and Inter-temporal Dilemma's

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Abstract: We investigate differences in decision-making by groups and individuals in a non-strategic inter-temporal choice problem and in an (strategic) inter-temporal common pool dilemma. Decision-makers are either individuals or groups of three individuals. Group decisions are made by way of anonymous proposals. Agreement is reached when two out of the three group-members submit the same proposal. Our hypotheses are as follows. First, based on the idea that 3 people are smarter than 1, we expect groups to make better choices than individuals in the inter-temporal dilemma, exhibiting longer time-horizons. As a consequence, we expect groups to earn more in the non-strategic inter-temporal choice problem. Second, based on the psychological literature, we expect groups to act more aggressively in the common pool dilemma (the so-called Discontinuity Effect) and as a result earn less than individual decision makers. Our data seems to confirm both these hypotheses.

1. Introduction

Many economic decisions are made by groups; households, boards of directors, teams of managers running an investment fund, etc. In experimental economics we (empirically) test economic theories by observing economic choices in controlled circumstances, but it's usually the behaviour on the individual level that is studied and we can't simply assume that groups make the same decisions as individuals.

There is a significant body of research in psychology comparing individual and group behaviour and decision-making. The psychological findings can very roughly, and with economic situations in mind, be divided into two main effects. Firstly, groups are often assumed make better decisions than individuals. This is based on the simple idea that two (or more) people know more than one. This effect depends on the decision at hand: there has to be a *demonstrable* right solution. Secondly, groups often make different decisions than individuals. On an individual level we can simply assume that a particular individual acts according to her preferences (if someone prefers A over B she will choose A). On a group level choices not only depend on how the individual preferences of the group-members are combined into a group-decision, but individual preferences can change because an individual is a member of a particular group.

One example of such an effect is the so-called polarization effect. This effect describes the finding that groups often make more extreme decisions than individuals. Decisions made collectively are often more extreme in the direction of the average of the individual decisions. For instance, if a number of individuals choose, on average, a slightly risky option in a particular decision, they are likely to exhibit a more risky choice when deciding as a group. Another example is the discontinuity effect. This effect describes the finding that groups often make more aggressive choices than individuals. This theory is mainly based on work done by Insko & Schopler (and various colleagues) on prisoner dilemma games. They find, time after time, that groups choose the competitive option more often than individuals (Schopler & Insko, 1992).

There is some research comparing individual- and group-behaviour in specific experimental economic situations. Because the topics covered are rather diverse and the results mixed it is hard, if not impossible, to draw any general conclusions from this research. There is some evidence that groups are indeed smarter (Bornstein & Yaniv (2002) in the ultimatum game, Mannix & Loewenstein (1994) for time-horizons) or at least learn faster (Kocher & Sutter (2005) for the beauty contest game). But, on the other hand, Cox & Hayne (2002) show that groups perform worse than individuals in a common value auction and Cason & Mui (1997) show that, in a dictator game, groups are in fact more altruistic than individuals.

In this paper we compare group- and individual performance in a time-dependent common pool dilemma. As a background story we were thinking of a lake with fish and one, or more, fishers (or, in the group-case, one or more fishing boats with a crew). Players affect each other via the price by deciding how much fish to catch – catching more increases the supply and lowers the price – but also have to take into account the consequences of their current actions on future periods – catching more now makes it more difficult, and costlier, to catch in the future.

The advantage of this kind of experimental problem is that it combines a number of different potentially interesting aspects of economic behaviour. By designing and running a number of separate experiments combining different attributes we hope to be able to compare the behaviour and come to a better understanding of the differences between decisions made by groups and individuals. In this particular case we first focus on a purely inter-temporal puzzle to try and find out whether groups are better at inter-temporal decision making than individuals and then use this result to interpret the findings of the second experiment, the inter-temporal common pool dilemma.

2. The Experiments

2.1 The Model

For fear of priming our participants we didn't use the lake-with-fish analogy in the experimental design. Instead, the experiments revolve around a pool filled with tokens. The purpose of the game is to earn money by taking tokens out of the pool. Each game starts with a pool with 600 tokens and lasts for ten rounds. After each round the number of tokens left in the pool is multiplied by a growth-rate of 1.1.

A player can be an individual or a group of three participants, deciding together how much to take out and sharing their earnings equally. The revenue per token in a particular round, in experimental francs, is calculated according to the following formula:

(1) $r_t = 250 – ¼.h_t – 120.000/x_t$

where r_t is the revenue per token in round t, h_t the amount of tokens taken out in round t and x_t the amount of tokens in the pool at the beginning of round t (so x_1 is 600). For a clearer understanding you might want to think of this formula as built from two parts with $250 – ¼.h_t$ being a simple demand function – the more is taken out, the lower the price per token – and $120.000/x_t$ as a fixed (per period) marginal cost function – the less tokens there are in the pool the more it costs to take them out. So, in any given period (except the final period) taking out the amount of tokens that maximizes the revenue for that period – i.e. ht = *2*(250 – 120.000/xt)* – will lead to a lower revenue in future periods. Maximizing the total, cumulative, 10-period revenue needs a certain level of *forwardlookingness* that allows a player to forego an immediate pay-off to reach a higher, long-term revenue.

The only difference between the two experiments described in this paper is the number of players that is active around the pool. When there is only one player – a group or an individual – per pool we have an inter-temporal puzzle, which we'd like to use to establish the level of *forwardlookingness* for each player. In the second experiment there are 3 players per pool, turning it into a strategic game with a inter-temporal aspect.

2.2 The Group Decision-Making Process

One important issue when comparing group and individual behaviour is the way in which the group reach their decision. There is surprisingly little attention for this issue in the existing experimental economic literature on this topic. In the existing research on group- vs. individual decision-making referred to above face-to-face discussion between group-members appears to be permitted in all cases but there seems to be no formal requirements for the way group decisions are made.

In the experiments covered in this paper we did formalize a specific group decision-making method. First of all there was no face-to-face discussion. Members of a particular group acted anonymously, each from behind their own computer. A limited form of communication was possible: group members could share proposals with each other. In each round each member could type in the number of tokens she proposed to take out. When all three members had done so the proposals were made known amongst the members of any group. A group decision was reached when any two members of a group proposed the same number. If such a level of agreement wasn't reached after the first round of proposals group members could adjust their proposals until two of them agreed over how much to take out.

The main advantage of this decision using making method is that it allows for much more control than other methods. It allows us to study any potential effects of groupmembership – from the initial proposals of individual group-members to the subsequent group-decision – in much more detail.

2.3 Procedure

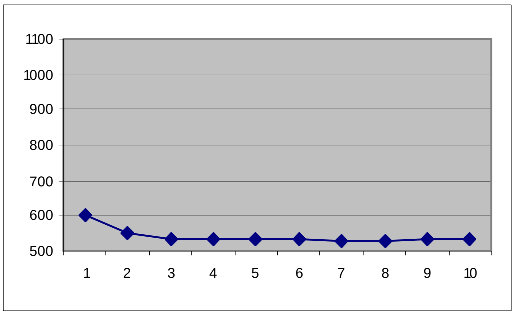
We ran the two experiments consecutively in one session. There were two conditions: a group- and a individual condition. Both conditions started with a practice round. For 10 minutes participants could, individually, try the inter-temporal puzzle for any number of times without being paid. After this the participants played one instance of the inter-temporal puzzle and three instances of the time-dependent common pool dilemma game, as individuals in the individual conditions and as groups of three in the group conditions. Participants were paid the earnings of the inter-temporal puzzle and of one randomly selected time-dependent pool dilemma game. We ran 3 individual sessions (= 48 players) and 5 group sessions (= 30 players).

3. Experiment 1: The Inter-Temporal Choice Puzzle

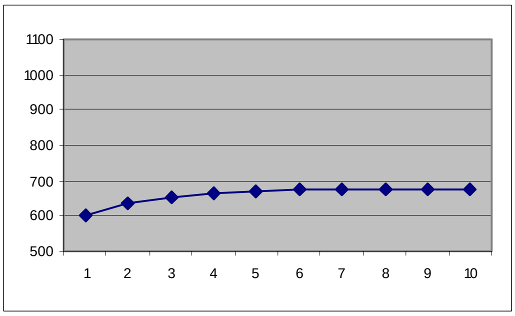
3.1 Experiment 1: Strategies

When there is one player per pool maximizing the cumulative, 10-round pay-off is a inter-temporal choice problem. The optimal strategy starts by taking out nothing in the first 5 rounds, taking out 32 tokens in round 6, 87 in round 7, 135 in round 9 and 181 in round 10. This will lead to a total revenue of 55.376 experimental francs. On the other extreme of the *forwardlookingness* scale we find the myopic player, each and every round solely maximizing the revenue of that particular period not taking the future consequences of its actions into account. This will lead to a harvest of 100 tokens in the first round (= 2*(250 – 120.000/size of the pool), 64 in the second, 51 in the third and alternately 48 and 49 for the rest of the game. This leads to a total cumulative pay-off of 8261 francs. Intermediate levels of *forwardlookingness* – say, players looking only at the current and the next round, players looking two periods into the future etc. – lead to different harvest paths and pay-offs.

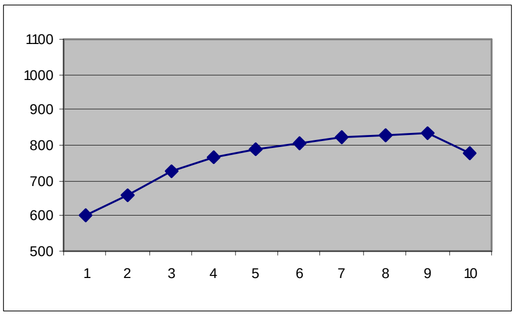
One way we can distinguish between the different strategies of players with different levels of *forwardlookingness* is at the development of the number of tokens in the pool as shown in figures 1A through 1F below.



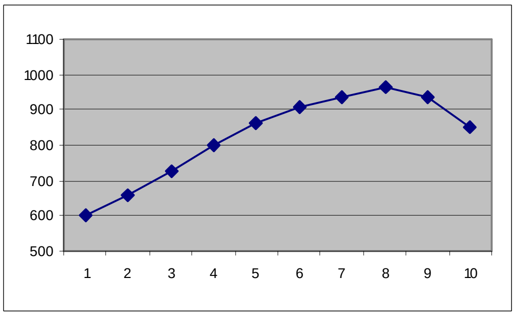
1A: 0 periods (myopic)



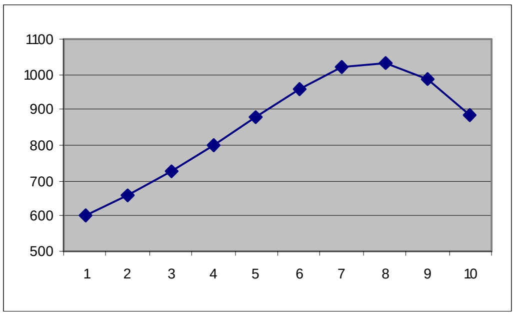
1B: 1 period



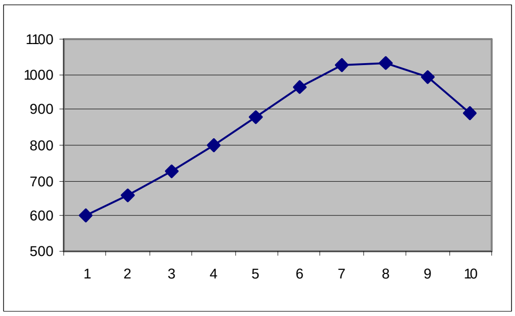
1C: 2 periods



1D: 3 periods.



1E: 4 periods



1F: 5 periods (= complete game)

Figures 1A-1F: development of the number of tokens in the pool for strategies with different levels of forwardlookiness in the inter-temporal choice puzzle

Of course, the optimal catch in any particular round for any level of *forwardlookingness* depends very much on how much tokens there are in the pool and, as such, on the history of the game. Only players playing a particular level of *forwardlookingness* in every period in the game will exhibit any of the graphs depicted above. Another, more global, measure of *forwardlookingness* in this game is the total cumulative pay-off: the more forward looking a player, the higher its revenue after 10 periods. Figure 2 describes this the nature of this relationship graphically.

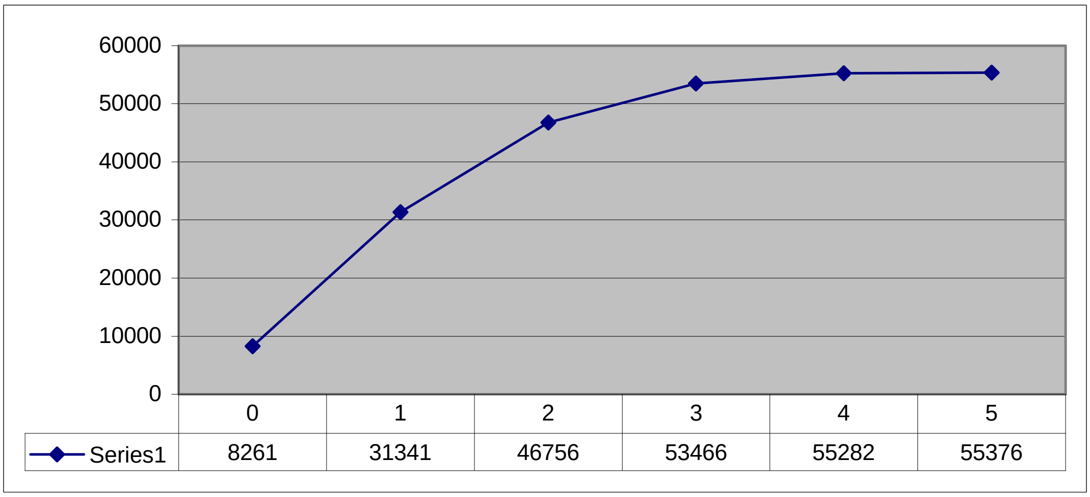


figure 2: total revenue for strategies based on different levels of forwardlookingness

Because a certain level of *forwardlookingness* leads to a particular level of total earnings and the more forward looking a player is the higher these earnings, we propose to use the total cumulative earnings as a measure of *forwardlookingness*. We want to use figure 2 to divide the players into different categories of *forwardlookingness*. Players earning between 0 and 19801 (= the halfway point between 8261 and 31341) francs are said to be myopic, looking not into the future at all. Players earning between 19801 and 39048 ½ (= the halfway point between 31341 and 46756) francs are said to be one-period forward looking. Etcetera.

Based on the idea that groups are smarter than individuals we expect groups to have a higher level of *forwardlookingness* and earn more than individuals.

3.2 Experiment 1: Results

Figure 6 depicts the development of the average size of the pool for both the group- as well as the individual condition. The differences between them aren't statistically significant in any period. For comparison's sake the development of the number of tokens in the pool in the case the optimal strategy is played is depicted as well.

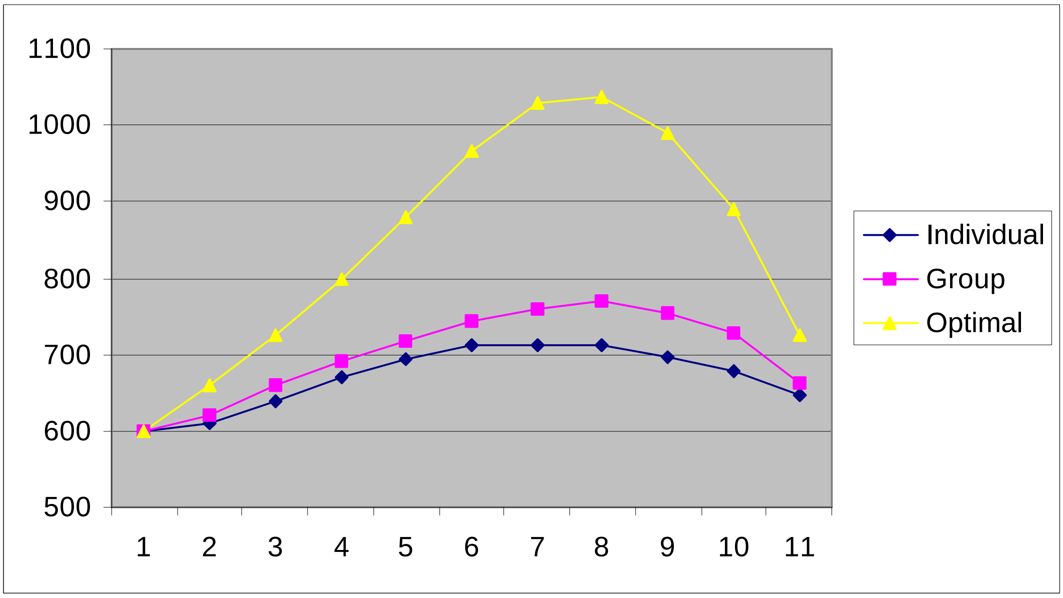


figure 6: average number of tokens in the pool per period per condition

Probably the most straightforward way to compare group and individual performance in the inter-temporal choice puzzle is to look at the total cumulative earnings. The better a player is at figuring out how its current actions influence its future pay-offs, the higher its revenue. Out of a possible 55376 experimental francs individuals earned on average 26576.87 (sd = 14536.97) and groups 32551.21 (sd = 13382.34). Using a Mann-Whitney test and a significance level of 10%, the difference is siginicant (p = 0.069). This suggests that groups are indeed better at solving the inter-temporal dilemma than individuals.

Figure 7 shows the percentual distribution of the different types of *forward-lookingness* over the group- and individual conditions. This is another way of seeing that groups are better at this game than individuals: there are less myopic players and more 2-period forward-looking players in the group- than in the individual condition.

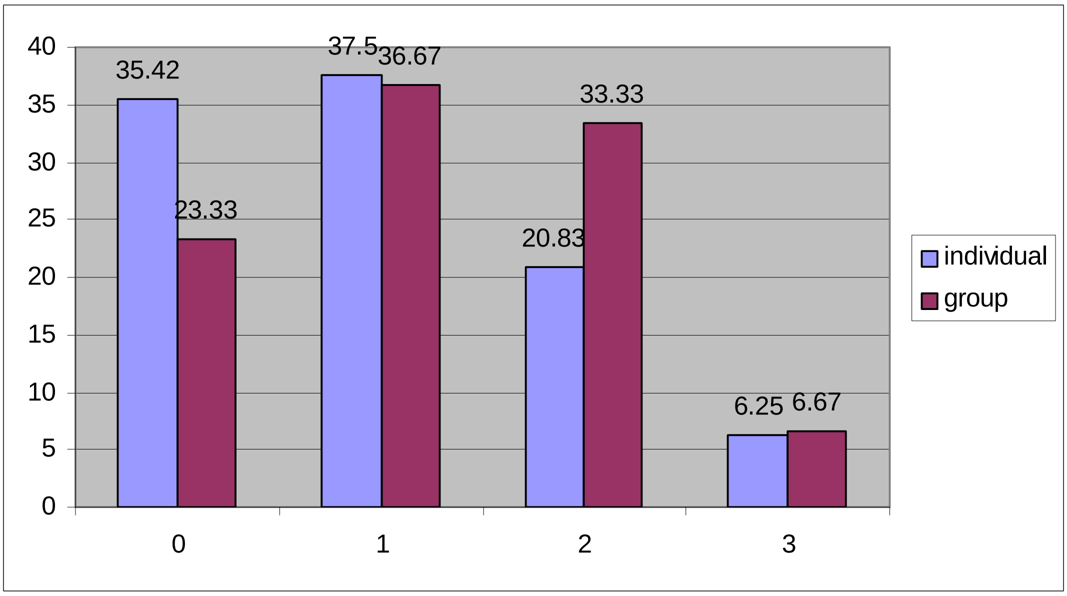


figure 7: percentages of forwardlookingness types per condition

3.3 Experiment 1: Discussion

Groups earn significantly more in our inter-temporal choice problem than individuals. This suggests that groups have a higher lever of *forwardlookingness*.

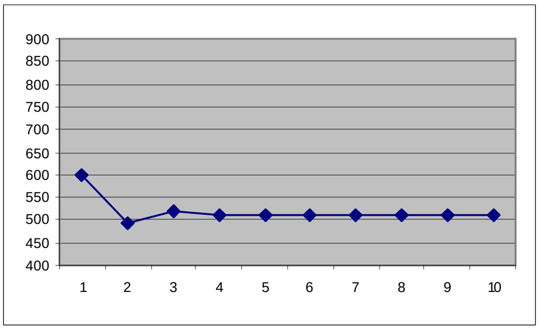
4. Experiment 2: Inter-Temporal Common Pool Dilemma

4.1 Experiment 2: Strategies

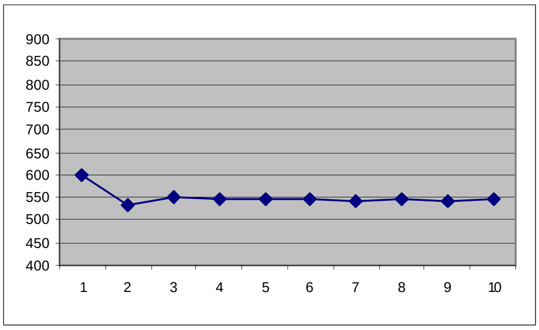
In the second experiment there are three players per pool. The h_t in formula 1 now depends on the decisions of all three players. This makes it a strategic game, which we call a inter-temporal common pool dilemma: The socially optimal strategy would be to let the combined number of tokens taken out in any particular round not to exceed the amount according to the optimal strategy in the one player case. But the *dilemma* arises because each player in the strategic game has the incentive to take out more: this will decrease the price per token but this is, up to a certain point, compensated by the increase in the size of the catch. But there is an additional consequence of taking out more than the socially optimal amount of tokens: this will decrease the amount of tokens in the pool in the next round and as a result increase the cost and decrease the revenue. This effects both the other players sharing the pool but also the player who does the overfishing. This is the inter-temporal effect we studied in the first experiment.

Calculating different solutions for this game is considerably more difficult than for the puzzle. For instance, if every player is perfectly forward looking ánd, not unimportantly, every player expects the other players to be perfectly forward looking the subgame perfect Nash-equilibrium is to take out nothing in the first 3 rounds, 15 tokens in the fourth, 35 in the fifth, 43 in the sixth, 46 in the seventh, 41 in the eighth, 33 in the ninth and 25 in the last. This will earn every player 11.858 francs. When every player is myopic ánd, again, every player thinks every other player is myopic the Nash equilibrium is to take out *250 – 120.000/poolsize* in every round. Leading to a harvest of 50 in the first round, 8 tokens in the next, 18 in the third and alternately 15 and 16 for the remainder of the game.

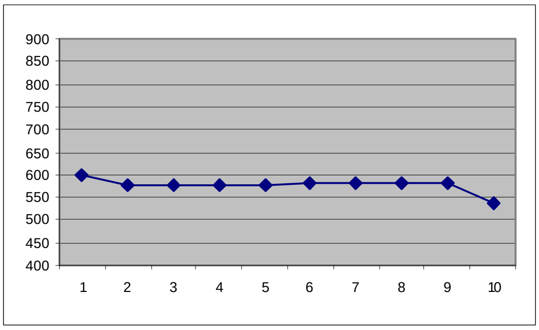
Here too, like for the puzzle, we can draw some graphs, figures 3A-G, depicting the development of the number of tokens in the pool for different levels of *forwardlookingness*. All these *solutions* depend on every player in the pool having a particular level of *forwardlookingness* ánd expecting the other players to be just as smart.



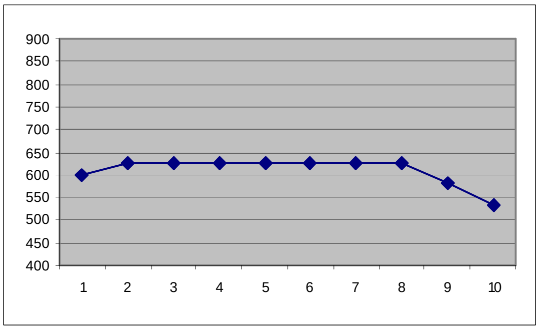
3A: zero periods (myopic)



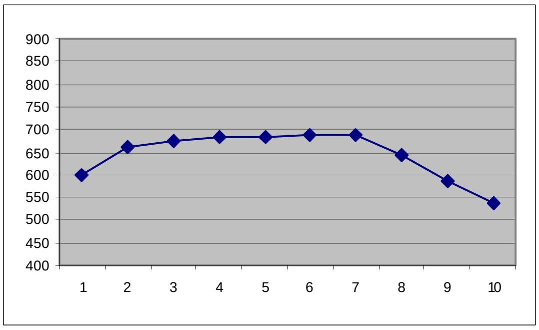
3B: 1 period



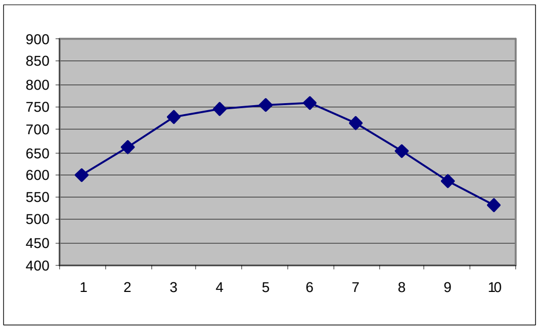
3C: 2 periods



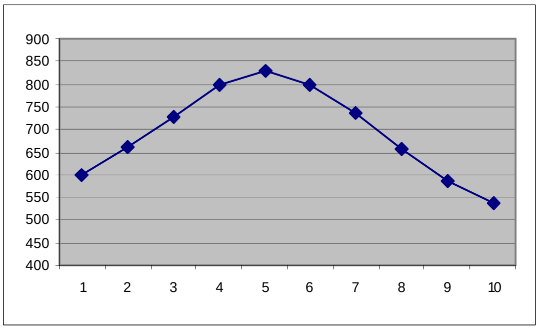
3D: 3 periods



3E: 4 periods



3F: 5 periods



3G: 6 periods (complete game)

Figure 3A-3G: development of the number of tokens in the pool for strategies with different levels of forwardlookiness in the inter-temporal common pool dilemma

And for the strategic game as well we can draw a graph depicting the different total cumulative earnings for different levels of forwardlookingness. Again these earnings assume that every player in the game has the same level of forwardlookingness and thinks the other players have too. Deviations from this assumption will make this game near impossible to solve.

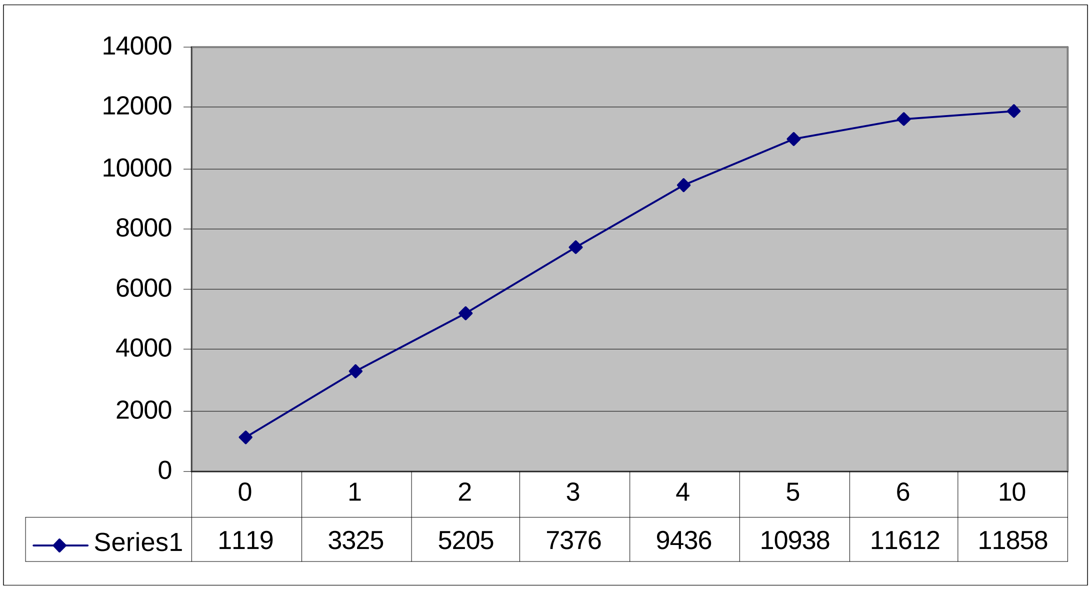


figure 4: total revenue for strategies based on different levels of forwardlookingness

One reason of doing these two experiments in one go is that it allows us to compare the performances of particular players in both situations. More specifically, we want to use the inter-temporal puzzle to determine the level of forwardlookingness for a player and use this to analyse the behaviour in the strategic, inter-temporal common pool dilemma, for both groups and individuals. Figure 5 describes the relationship between the earnings (as fraction of the total possible earnings ie the earnings of solving the complete game) in the inter-temporal puzzle and the earnings in the inter-temporal common pool dilemma for any given (average) level of forwardlookingness. For instance, a player playing a strategy of looking 2 periods into the future earns in 84% of the total potential earnings in the inter-temporal choice problem. A pool consisting of three players playing (Nash-)strategies with an average of two periods forwardlookingness would earn 44% of the total potential (Nash-)earnings in the inter-temporal common pool dilemma.

So, figure 5 describes our expectations of the revenue of a particular pool in the inter-temporal common pool dilemma – assuming everybody plays their Nash-strategy – based on the average earnings of the players sharing the pool in experiment 1.

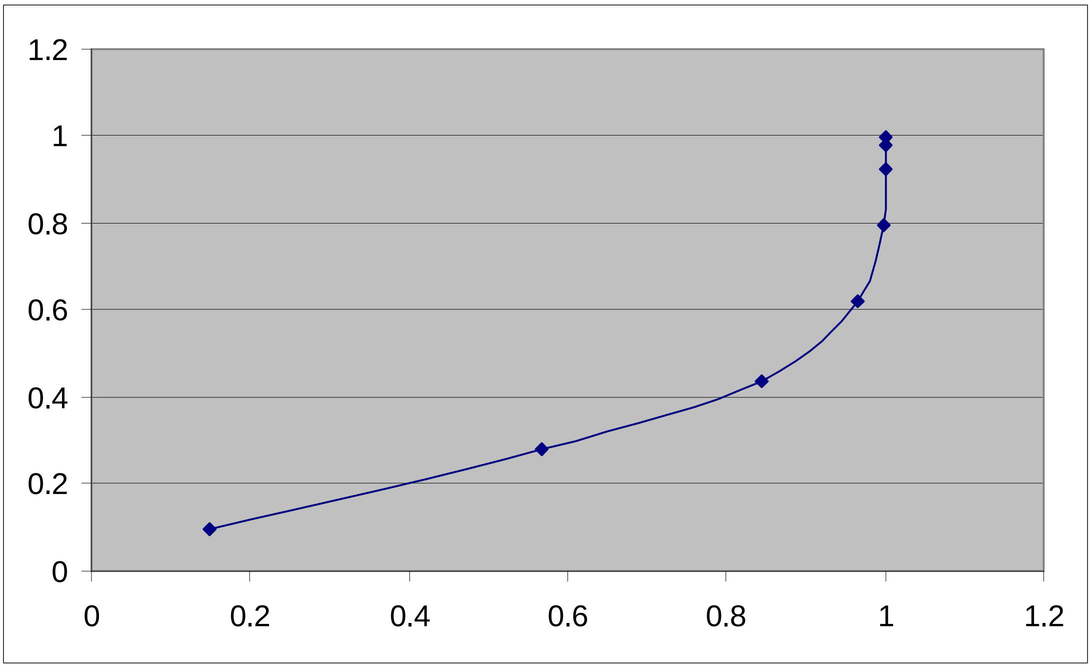


figure 5: relationship between earnings in the inter-temporal puzzle and the inter-temporal common pool dilemma for given levels of forwardlookingness.

From experiment 1 we learned that groups look further into the future than individuals. Groups earned 59% of the total possible amount; individuals 48%. Using figure 5 we expect groups to earn approximately 29% of the total possible pay-offs in the second experiment, and individuals approximately 23%. That is, if we don't account for any potential effects on the competitiveness of groups. If, as the discontinuity effect predicts, groups are more aggressive than individuals, this difference will disappear and if this effect is strong enough groups will even earn *less* than individual players.

4.2 Experiment 2: Results

Figure 6 depicts the development of the average size of the pool for both the group- as well as the individual condition. For comparison's sake the development of the number of tokens in the pool in the case the optimal strategy is played is depicted as well. Although in the first few rounds the average size of the pool is larger for groups, groups do perform worse than individuals from round 4 on (the difference in the amount of tokens in the pool is actually only significant in round 5. *Cijfers!!*).

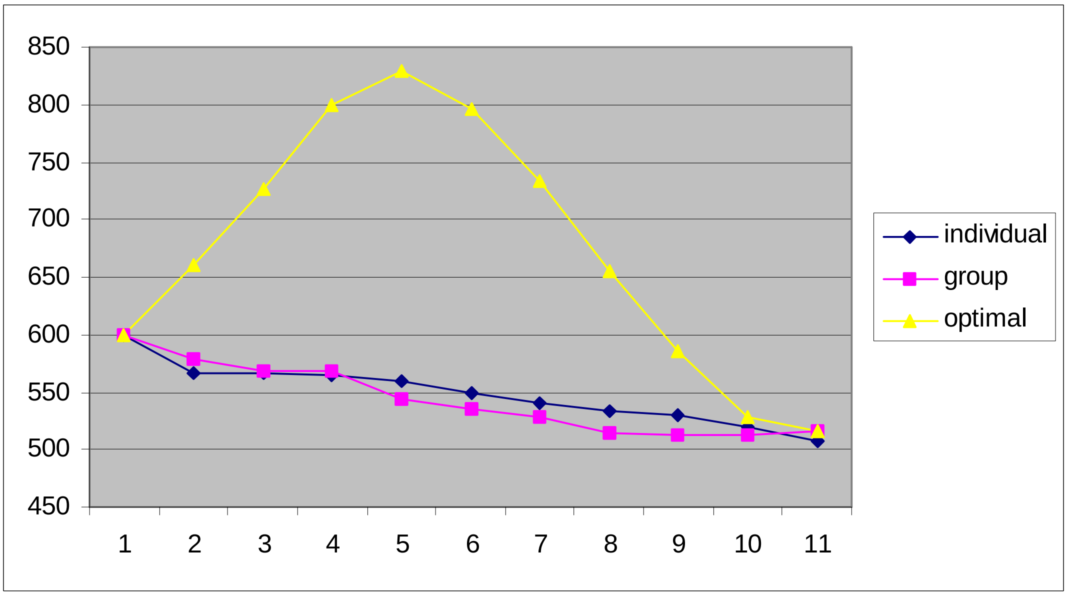


figure 8: average number of tokens in the pool per period per condition

Interpreting the results of the inter-temporal, strategic game is a little more difficult than it is in the case of the inter-temporal puzzle. For instance, the earnings of a particular player are very much dependent on the actions of the other players in its pool. Comparing the total cumulative earnings it is therefore probably best to look at it from a pool-level. On average group-pools earned a grand total of 8222.77 (sd = 6768.5) experimental francs whereas the individual-pools earned on average 9798.23 (sd = 9885.81). This difference is, according to a Mann Whitney-test nót significant (p = .339). (When we look at it from a player level, the difference is (almost) significant: 3262.2 (3856.06) vs. 2740.92 (3123.06), p = 0.071).

Using figure 4 we can divide the pools in different categories according to their level of *forwardlookingness*. Figure 9 describes this distribution.

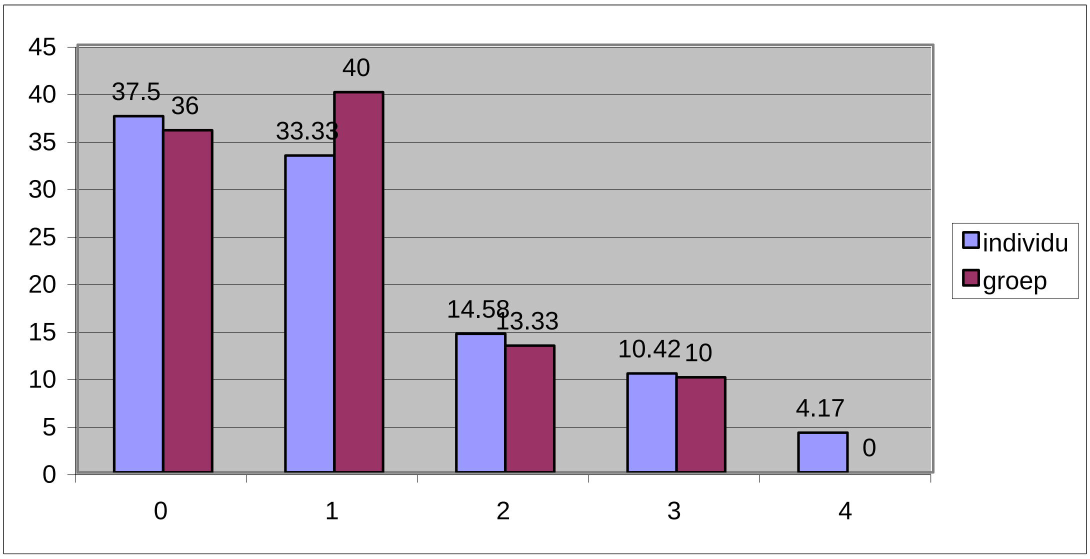


Figure 9: percentages of forwardlookingness types per condition

Figure 10 relates the average score of the three players who form a pool in the second game in the puzzle and the strategic game. The benchmark-line is based on the idea that players who, on average, exhibit a certain level of forwardlookingness in the puzzle are assumed to play their nash-equilibrium-strategy for that level of forwardlookingness in the strategic situation (see also figure 5). Players on the southeast side of the benchmark-line perform, given their exhibited level of forwardlookingness in the puzzle, sub-par in the strategic game. Players on the northwest side of the line perform better in the strategic game than could be expected from their performance in the inter-temporal puzzle.

The majority of the group-pools (6 out of 10) can be found on the south-east side of the benchmark-line, whereas the majority of the individual pools (9 out of 16) are north-west of the benchmark. On average, we would expect groups to earn 29% of the potential earnings in the inter-temporal common pool dilemma, which is 10316 francs per pool. In fact they earned, on average, 8223 francs. For individuals, based on their earnings in the first experiment, we would expect them to earn 23% of the total potential earnings, which is 8182 per pool, but individuals did in fact earn 9798 on average per pool.

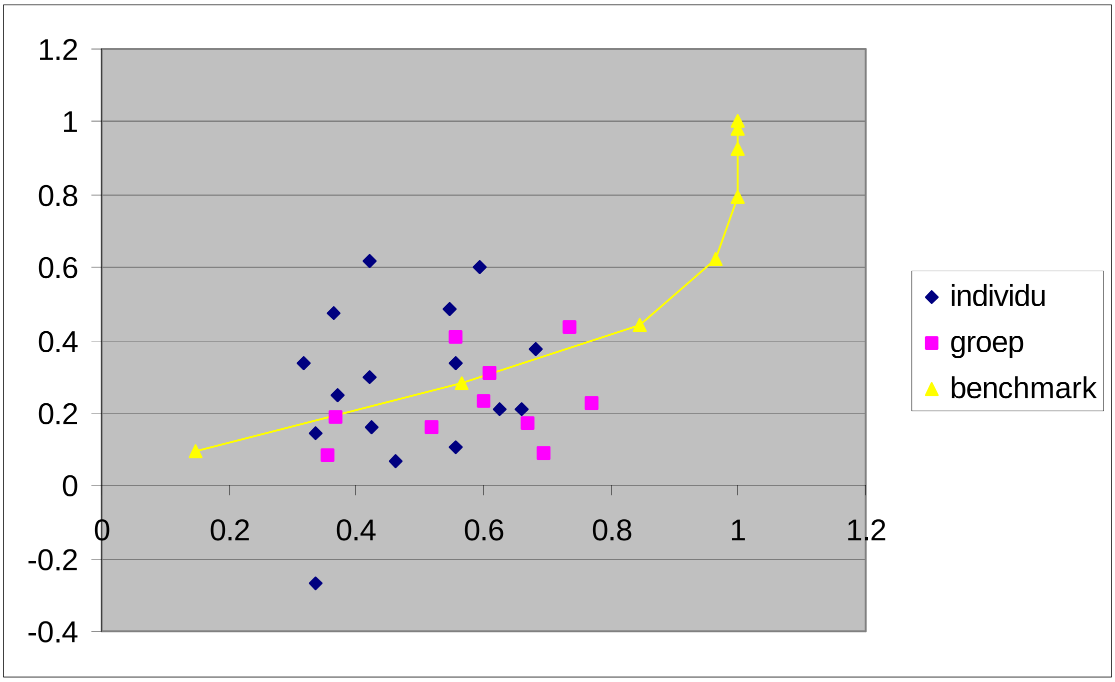


figure 10: the relationship between total earnings (as fraction of total possible earnings) in experiment 1 and experiment 2 for each pool.

4.3 Experiment 2: Discussion

Although we can't say that groups earned significantly less than individuals in the inter-temporal common pool dilemma, it is remarkable that groups did earn less then expected on the basis of their performance in the inter-temporal choice problem whereas individuals earned more than we expected them to. It appears that despite our finding from experiment 1, that groups are better at solving the inter-temporal problem presented in our model, they appear not to be able to translate this smartness in a strategic situation. The discontinuity effect – stating that groups choose more aggressively in strategic situations – could be an explanation for this finding.

5. Conclusions

We find that groups are better than individuals at solving an inter-temporal choice problem, which we see as confirmation for the hypothesis that groups are smarter than individuals. In a situation where we add a strategic aspect to the inter-temporal dilemma the finding that groups are inter-temporally smarter than individuals seems to disappear. This could be seen as proof for the theory that groups are more aggressive than individuals (the discontinuity effect) but for real confirmation of this hypothesis in this situation more research is needed. Luckily we've created the experimental method such that we can quite easily run an experiment looking at, for instance, only the strategic issue of the model and compare this with the results presented here.

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