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Abstract

A dynamic decision making experiment recently conducted on individuals suggested that people may look ahead but seem either unable or unwilling to predict their own future behaviour. In order to distinguish between these two possibilities, we repeated the experiment with pairs of individuals. The experiment consisted of two decision nodes (interleaved with two chance nodes), with one of the pair choosing at the first decision node and the second of the pair choosing at the second. Given the structure of the experiment, it was simple for the first player to predict the decisions of the second player. Nevertheless, the decisions of the first player indicate strongly that the first player does not in fact do so. It seems that people are unwilling to predict not only their own future behaviour but also the future behaviour of others.

Keywords: planning, prediction, dynamic decision making, pairs, individuals.

JEL codes: C91, C92, D81, C61

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1. Introduction

The results of a recent experiment on dynamic decision making by individuals (Hey 2005) suggested that individuals were unable or unwilling to predict their own future behaviour. This may have been for a variety of reasons, including their own inability or unwillingness to anticipate their own future preferences. This was despite the fact that their future behaviour was predictable (a fact which was confirmed in the experiment itself). In order to try and understand what was driving these results, we repeated the experiment using pairs of individuals rather than just with individuals (Bone *et al* 2005). The idea behind this design was that the subjects in the experiment were implicitly invited to think about what the other subjects were likely to do in the future. The structure of the experiment was the same as the individual experiment in that future behaviour of the other subjects was predictable (a fact that was once again confirmed in the experiment itself). We had expected that the subjects in the pairs experiment were more likely to take into account the future behaviour of the other subjects. Surprisingly, this turned out not to be the case.

2, The Structure of the Experiment

This is best illustrated with an example. Consider Figure 1, which contains a decision tree. There are two (sets of) decision nodes and two (sets of) chance nodes. The former are those labelled with a 'D' in Figure 1 and the latter those labelled with a 'C'. The players start at the left-hand decision node and proceed through the tree – eventually reaching a payoff node (one of those labelled with a 'P' in the figure). The payoff for **each** player was that in the payoff node reached – so there was no conflict of interest between the two players. At the chance nodes, Nature moves – and moves in such a way that Up and Down are equally likely and independent of any past moves either by Nature or by the players. In the individual experiment, one individual took the decisions at both decision nodes. In the pairs experiment, one of the pair (whom we call Player 1) took the decision at the first decision node, and the other of the pair (Player 2) took the decision at the second decision node. Crucially, in the pairs experiment, the two players could not communicate

with each other. Nor did they know the identity of their partner, either during the experiment or after.

Consider first the decision of Player 2 in the pairs experiment. Obviously, his or her decision will depend upon which of the four second decision nodes that he or she is at when taking the decision. Let us consider them in turn. If he or she is at the top second decision node, the optimal decision is clearly Down, as that leads to either £16 or £8 (both equally likely) while Up leads to either £8 or £13 (again both equally likely). This, of course, presumes that the preferences of the player satisfy dominance – a presumption that we shall take as given from now on. Similarly, Up is the optimal decision at the second of these second decision nodes (getting £20 or £6 instead of £18 or £6), Up at the third (getting £15 or £17 instead of £2 or £4) and Up at the fourth (getting £20 or £8 instead of £8 or £0). Note crucially that we need only to assume that the preferences of all the players respect dominance in order to make these predictions.

Armed with these predictions, we can now consider the optimal decision of Player 1 – who takes the decision at the first decision node. He or she can work out that if he or she chooses Up at this first decision node, then the payoff will be one of £16, £8, £20 or £6 (all equally likely), while if he or she chooses down then the payoff will be one of £15, £17, £20 or £8 (all equally likely). It is clear that the four equally-likely numbers, 15, 17, 20 and 8, first-order stochastically dominate the four equally-likely numbers, 16, 8, 20 and 8. So the optimal decision for Player 1 is to choose Down at the first decision node. Note, once again, that this prediction relies only on the non-violation of dominance in the preferences of the players. So, in this tree, Down is the optimal decision of Player 1. Contrariwise, Up is the wrong decision. Superficially, it could be motivated by the fact that the 8 payoffs in the top half of the tree (8, 13, 16, 8, 6, 20, 6, 18) look more attractive than the set of eight payoffs in the bottom half of the tree (15, 17, 2, 4, 20, 8, 8, 0). In fact, if each of the eight numbers in each half were equally likely, then it is the case that the set of 8 numbers in the top half of the tree first-order dominate the set of 8 numbers in the bottom half of the tree. But, of course, this line of argument leads us nowhere – as it ignores the future decisions of Player 2.

All the trees in our experiment had this property – which we call the *dominance property*. What we mean by this is that one decision at the first decision node appears to be optimal if Player 1 does not think ahead to what Player 2 is going to do, whereas the other decision is in fact optimal if Player 1 does think ahead and eliminate the payoffs which Player 2's future decision will avoid (assuming throughout that both players' preference functionals satisfy dominance). More specifically, the 8 numbers in one half of the tree first-order stochastically dominate those in the other half, while after elimination of the payoffs that will be excluded by Player 2's decision, the opposite is true – the four numbers remaining in the latter half first-order stochastically dominate the four numbers in the former half. This dominance property enables us to test whether subjects are thinking ahead to future decisions.

3. The experiment

The experiment was computerised and implemented at the laboratory of **EXEC**, the Centre for Experimental Economics at the University of York. When the subjects arrived, they were given written Instructions (see the Appendix), and the first ten minutes of the experiment were allocated to them reading the Instructions. Then a PowerPoint presentation was played at a predetermined speed on their individual and screened computer terminals – repeating the Instructions and giving more details as well as examples of the tree. At this point, the subjects had the opportunity to ask any questions. It was impressed on them that there was no time constraint.

A total of 55 subjects participated in the individual experiment and 52 in the pairs experiment (the latter divided into 26 pairs). All subjects were given four separate attempts at the tree, the intention being to see if experience affected behaviour. For each pair and on each attempt, the set of payoffs was different – though all the trees had the dominance property, which we defined and discussed earlier. In addition, all payoff sets had two further properties. Let us suppose that Up (Down) is the correct decision at the first decision node. Then the first further property was that the arithmetic mean of the 8 payoffs in the bottom (top) half of the tree was at least £2.50 higher than

the arithmetic mean of the 8 payoffs in the top (bottom) half of the tree. The second further property was that the expected payoff playing Up (Down) at the first decision node was always at least £2.50 more than the expected payoff playing Down (Up) at the first decision node. All the payoffs were integers in the range from 0 (pounds sterling) to 20 (pounds sterling). Moreover, the branches of the tree were randomly changed from tree to tree so that the correct decisions at the various nodes varied from tree to tree. After completing all four attempts, the subjects (always individually, whether in the individual experiment or in the pairs experiment) called over an experimenter and each subject was paid in cash a randomly chosen one of the payoffs on the four attempts at the experiment. (We should note that the use of this *random lottery incentive mechanism* should not create problems in this particular experiment as the whole experiment is driven by dominance – so changing expected wealth through the experiment should not affect behaviour.) The subjects completed a very brief questionnaire and signed a receipt.

4. The Experimental Results

The first key result concerns the decisions made at the second decision node. Table 1 gives the details. In this, we refer to a decision which respects dominance as a correct decision and one which violates dominance as an incorrect decision. It is clear from this table that almost all the

Table 1: decisions at the second decision node

	first attempt		second attempt		third attempt		fourth attempt		all attempts	
	correct	incorrect	correct	incorrect	correct	incorrect	correct	incorrect	correct	incorrect
individuals	52	3	54	1	54	1	54	1	214	6
pairs	25	1	24	2	24	2	24	2	97	7

decisions at the second decision node respected dominance. Note that this is true throughout all four attempts – and it should have become obvious to all subjects as the experiment progressed – even if it was not obvious at the beginning. This should have had an effect on the decisions at the first node. Table 2 gives the details, where we refer to a decision which respects dominance and the anticipation of the second decision as a correct decision, and to a decision which does not as an incorrect decision.

Table 2: decisions at the first decision node

	first attempt		second attempt		third attempt		fourth attempt		all attempts	
	correct	incorrect	correct	incorrect	correct	incorrect	correct	incorrect	correct	incorrect
individuals	19	36	21	34	19	36	15	40	74	146
pairs	5	21	9	17	9	17	9	17	32	72

It is very clear from this that the majority of the decisions at the first node, both in the individual experiment and in the pairs experiment, were incorrect. The percentages correct were 33.6% and 30.8% – both significantly different from 50% (t-stats 5.2 and 4.2 respectively), but not significantly different from each other (t-stat 0.51). What is also interesting from the above table, is that the subjects did not seem to improve with experience – if anything, slightly the converse.

A more formal analysis is obtained by trying to explain the decisions of the subjects.

Let us denote by d the decision of the subject, with $d = 0$ indicating an incorrect decision and $d = 1$ indicating a correct decision. We try to explain the observed values of d using a probit analysis, with at first the following independent variables: a the attempt number (taking values 1, 2, 3 and 4); n the node number (taking values 1 and 2); and iop a dummy variable taking the value 0 for data generated in the individual experiment and taking the value 1 for data generated in the pairs experiment. We obtained the following equation (where Z denotes the latent variable such that $d = 1$ if $Z > 0$ and $d = 0$ if $Z \leq 0$ (and where the numbers in parentheses are t-ratios):

$$(1) \quad Z = -2.65 + 0.0034a + 2.24n - 0.149iop \quad ll = -255.5 \quad n = 648$$

$$(10.9) \quad (0.06) \quad (15.0) \quad (1.1)$$

What this equation is telling us is that: (a) experience has no effect; (b) the node number has a major effect – with a much higher probability of getting the correct decision at the second node; (c) that the pairs are somewhat less likely than individuals to get the decision correct. However, this latter effect is not significant. In future probits we drop the variable a as it is never significant.

We also collected data on the time taken by the subjects to take their decisions. For the first decision node, the time taken was the number of seconds between the subject seeing the tree and confirming his or her decision at that first node. For the second decision node, the time taken was the number of seconds between Nature's first move and the subject confirming his or her decision at that second node. Let us denote this time by *time*. After trying a number of different formulations, the following emerged as the best.

$$(2) \quad Z = -3.27 + 2.45n + 0.0133time - 0.0083iop*time \quad ll = -247.1 \quad n = 648$$

$$(13.1) \quad (15.5) \quad (4.0) \quad (2.6)$$

This indicates that the decision accuracy of individuals improved with the time spent taking the decision, whereas the decision accuracy of those taking the experiment in pairs improved only marginally (and certainly not significantly) with the time they spent considering the decision. Note that we are not saying that the individuals spent more time on decision making (in fact, the opposite was true, with individuals spending on average 22.6 seconds on each decision and pairs spending on average 34.2 seconds per decision), it is just that the more time that the individuals spent, the more accurate were their decisions. This does not seem to be the case for those taking the experiment in pairs. However, the magnitude of the effect should be taken into consideration: if the *time* for an individual increased by 2 standard deviations, the above equation implies that Z would increase by 0.575, and thus (starting from 0) the probability of a correct decision would increase by 0.22.

We also collected some primitive demographic variables on the subjects. In particular, we recorded their age, sex, year of study and degree. We investigated whether any of these

demographics improved the explanation of d . The only one that did was sex (a dummy variable taking values 0 for men and 1 for women). Including this in our probit gives us the following – our best equation.

$$(3) \quad Z = -3.14 + 2.47n + 0.0125time - 0.0068iop * time - 0.29sex \quad ll = -244.6 \quad n = 648$$

(12.2) (15.4) (3.7) (2.1) (2.2)

Women seem to be 11% more likely to take the incorrect decision.

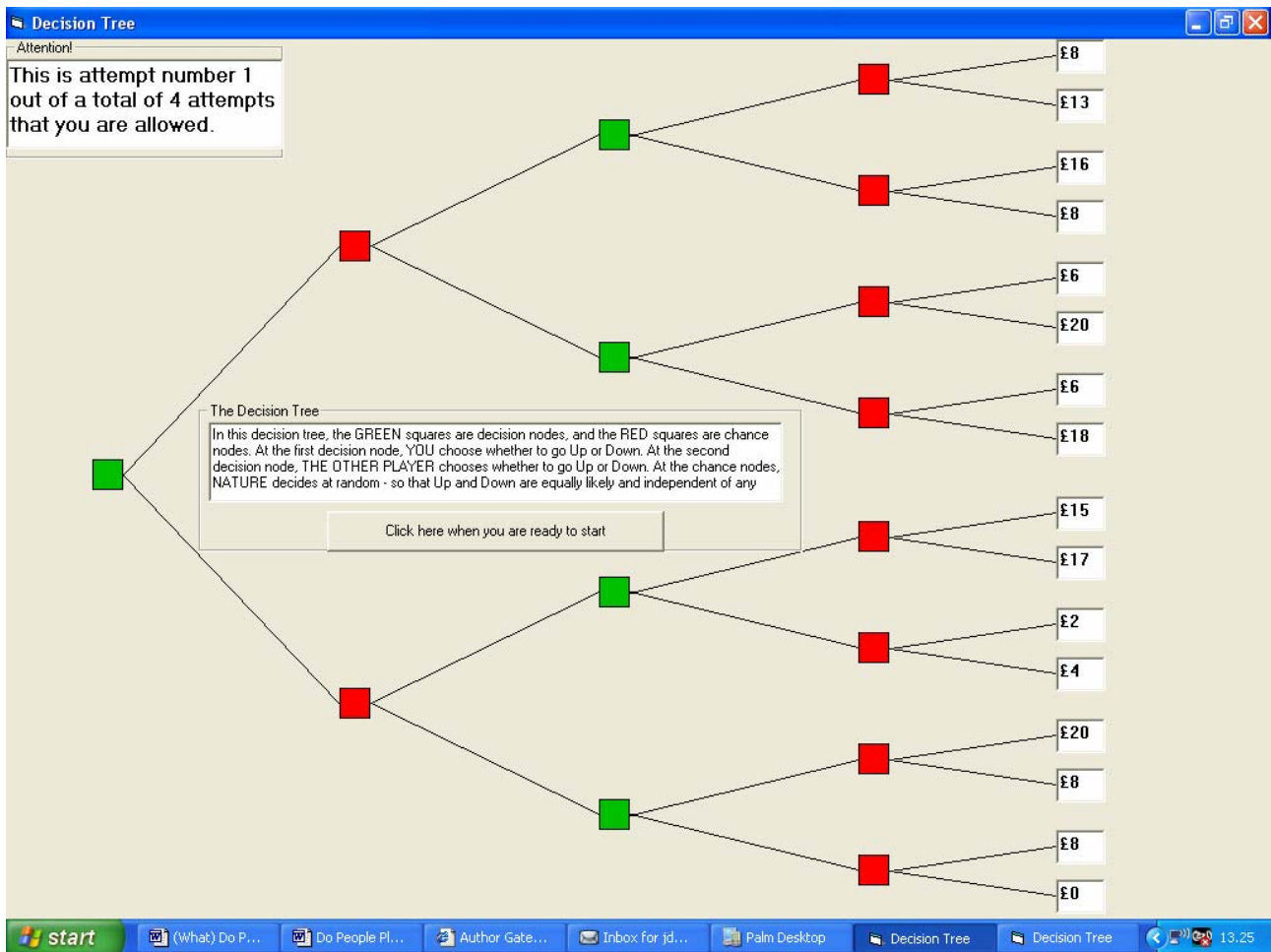
4. Conclusions

References

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Figure 1: An example of the decision tree



D

C

D

C

P

Appendix 1: Instructions for the Individual Experiment

INSTRUCTIONS

Welcome to this experiment. It is an experiment on the economics of dynamic decision making under risk. The Economic and Social Research Council of the UK (ESRC) has provided the funds to finance this research. The instructions are straightforward, and if you follow them carefully you may earn a considerable amount of money which will be paid to you in cash immediately after the end of the experiment. Please read the instructions carefully and take as much time as you need. There are no right or wrong ways to complete the experiment, but what you do will have implications for what you are paid at the end of the experiment. There is no participation fee for this experiment – what you are paid at the end depends partly on the decisions that you take during the experiment and partly on chance. At the end of the experiment you will be asked to sign a receipt for any payment that you received, and to acknowledge that you participated voluntarily in the experiment. The results of the experiment will be used for the purpose of academic research and will be published in such a way that your anonymity will be preserved.

The Experiment

The experiment concerns a *Decision Tree*. This decision tree is simply a short sequence of decisions to be taken by you, interlaced with moves taken by Nature. Nature is a random device, representing risk, whose behaviour will be explained to you shortly. Each sequence of decisions by you and moves by Nature leads to a payoff, which is an amount of money. You will be allowed several attempts at the decision tree. On each attempt there will be a payoff, denominated in money. Your payment for participating in this experiment will be one of these payoffs – chosen at random from the set of payoffs on the various attempts that you will have completed.

The Decision Tree

The *Decision Tree* is characterised by a sequence of *decision* and *chance nodes*. At each node there two subsequent paths to follow: Up and Down. At each *decision node* **you** will have to take a *decision* - in each case whether to go Up or Down. At each *chance node* a chance device - which we call **Nature** - will determine whether Up or Down is chosen. Nature operates in a totally random way – so that Up and Down are equally likely and independent of any past moves either by you or Nature. In total there are *two* decision nodes and *two* chance nodes, starting with a *decision* node and then alternating the two types until the final *chance* node. So the entire sequence is: decision, chance, decision, chance. After the second and final chance node is played out you will arrive at an *end node*. Each *end node* has associated with it a *payoff* - an amount of money. The payoffs associated with each end node are written in the end nodes.

Nature

‘Nature’ is our way of describing a totally random device. It is important that you understand what this means. At any chance node, when Nature moves, it moves in such a way that Up or Down are equally likely and independent of any moves made by you or by Nature at any time. This means that it is impossible to predict what Nature is going to do and the only information

on which you can work is simply that Up and Down are equally likely. It may be useful to you to note that the way that Nature is implemented on the computer is through using the random number generating mechanism of the computer software. Even with this knowledge you are unable to predict any move of Nature.

The Various Attempts

You will be allowed several attempts at the tree. The several attempts are all independent of each other. In particular, the moves by Nature in one attempt are independent of the moves by Nature in other attempts. Moreover, there is no reason why your moves should not be independent – but those decisions are entirely up to you: your decisions on any one attempt are not in any way constrained by what you decided on other attempts. Your decisions are entirely up to you – though obviously your payment will depend on what you decide. The basic *structure* of the tree will remain the same from attempt to attempt, in the sense that there will always be a decision node, then a chance node, then a decision node, then a chance node and then a payoff node, in each attempt. Moreover, Nature will always behave completely randomly. **The one thing that will differ from attempt to attempt is the set of payoffs. You should therefore carefully check the set of payoffs on each attempt.**

Your Payment for Participating in the Experiment

As we have already remarked, you will be allowed several attempts at the tree. The precise number of attempts will be told to you when you start the experiment, and you will be reminded throughout of how many attempts you have done and how many remain to be done. On each attempt there will be a *payoff*, denominated in money. Your payment for the experiment will be a randomly chosen one of these payoffs. For example, suppose you are allowed 4 attempts at the tree. There will be 4 payoffs – one for each attempt. At the end of the experiment, you will be invited to call over one of the experimenters. He or she will have 4 cards, numbered from 1 to 4. These cards will be shuffled and you will be invited to pick one of the cards (obviously without seeing the number written on it). The number on the card that you pick will be noted and you will be paid the payoff on that numbered attempt.

How the Experiment will Proceed

The experiment will begin with a PowerPoint presentation of these Instructions. Then you will turn to the experiment itself. The opening screen displays the EXEC logo. When everyone is ready to start, the EXEC logo will disappear. You will then be told how many attempts at the tree you will be allowed. The decision tree will then be displayed. You should study this carefully, and particularly the various possible end (payoff) nodes. You will end up at one of these payoff nodes in any one attempt. You will then be invited to work through the tree, starting at the left-hand node, which is a decision node. At each decision node, you will be asked to indicate whether you want to move Up or Down and then you will be asked to confirm your decision by clicking on the button “Click here to confirm”; your decision will then be implemented, with the part of the tree that your decision has excluded turning grey to indicate that that part is no longer available. At each chance node, you will be asked to get Nature to move by clicking on the button “Click here to get Nature to move”; you will then be told the move by Nature, and it will be implemented, with the part of the tree that Nature’s move has excluded turning grey to indicate that it is no longer available. After the

second and final move by Nature, you will see that only one end (payoff) node remains available. This is the payoff for that attempt.

The end of the experiment

After you have completed all the attempts, the **EXEC** logo will once again be displayed, along with a message informing you that the experiment is over. The message will also list the payoffs on the various attempts. At this point, you should call over one of the experimenters. He or she will then carry out the procedure described above for determining your payment for the experiment. He or she will ask you to complete a brief questionnaire and will pay you your payment. You will be asked to sign a receipt for the payment.

Other

If there is any aspect of these instructions about which you are not clear, please ask the Experimenter. It is clearly in your interests to understand these instructions as fully as possible. Please also feel free to call the Experimenter at any time.

THANK YOU FOR YOUR PARTICIPATION

Appendix 1: Instructions for the Pairs Experiment

INSTRUCTIONS

Welcome to this experiment. It is an experiment on the economics of dynamic decision making under risk. The Economic and Social Research Council of the UK (ESRC) has provided the funds to finance this research. The instructions are straightforward, and if you follow them carefully you may earn a considerable amount of money which will be paid to you in cash immediately after the end of the experiment. Please read the instructions carefully and take as much time as you need. There are no right or wrong ways to complete the experiment, but what you do will have implications for what you are paid at the end of the experiment. There is no participation fee for this experiment – what you are paid at the end depends partly on the decisions that you take during the experiment, partly on the decisions taken by someone else and partly on chance. At the end of the experiment you will be asked to sign a receipt for any payment that you received, and to acknowledge that you participated voluntarily in the experiment. The results of the experiment will be used for the purpose of academic research and will be published in such a way that your anonymity will be preserved.

The Other Player

You will be doing this experiment with another player. You will not know who this other player is, and he or she will not know who you are. The other player is one of the other participants in this session of the experiment and is present in this same room. Even at the end of the experiment, you will not know who the other player was, and he or she will not know who you were. In these instructions, we refer to you and the other player as Player 1 and Player 2, not necessarily respectively. Player 1 takes the first decision and Player 2 the second. You will be told at the beginning of the experiment whether you are Player 1 or Player 2.

The Experiment

The experiment concerns a *Decision Tree*. This decision tree is simply a short sequence of decisions to be taken by you and the other player, interlaced with moves taken by Nature. Nature is a random device, representing risk, whose behaviour will be explained to you shortly. Each sequence of decisions by you and the other player and moves by Nature leads to a payoff, which is an amount of money. You will be allowed several attempts at the decision tree. On each attempt there will be a payoff, denominated in money. Your payment for participating in this experiment will be one of these payoffs – chosen at random from the set of payoffs on the various attempts that you will have completed. The payoffs of the other player will be exactly the same as you. You and the other player have common interests.

The Decision Tree

The *Decision Tree* is characterised by a sequence of *decision* and *chance nodes*. At each node there two subsequent paths to follow: Up and Down. At each *decision node* **you or the other player** will have to take a *decision* - in each case whether to go Up or Down. At each *chance node* a chance device - which we call **Nature** - will determine whether Up or Down is chosen. Nature operates in a totally random way – so that Up and Down are equally likely and independent of any

past moves either by you or Nature. In total there are *two* decision nodes and *two* chance nodes, starting with a *decision* node and then alternating the two types until the final *chance* node. So the entire sequence is: decision, chance, decision, chance. At the first decision node, Player 1 takes the decision; while at the second node, Player 2 takes the decision. After the second and final chance node is played out you will arrive at an *end node*. Each *end node* has associated with it a *payoff* - an amount of money. The payoffs associated with each end node are written in the end nodes.

Nature

‘Nature’ is our way of describing a totally random device. It is important that you understand what this means. At any chance node, when Nature moves, it moves in such a way that Up or Down are equally likely and independent of any moves made by you or by Nature at any time. This means that it is impossible to predict what Nature is going to do and the only information on which you can work is simply that Up and Down are equally likely. It may be useful to you to note that the way that Nature is implemented on the computer is through using the random number generating mechanism of the computer software. Even with this knowledge you are unable to predict any move of Nature.

The Various Attempts

You and the other person will be allowed several attempts at the tree. You and the other person will stay together throughout these attempts, and Player 1 will always decide first; while Player 2 will always decide second. The several attempts are all independent of each other. In particular, the moves by Nature in one attempt are independent of the moves by Nature in other attempts. Moreover, there is no reason why your and the other person’s moves should not be independent – but those decisions are entirely up to you and the other person: your decisions on any one attempt are not in any way constrained by what you decided on other attempts. Your decisions are entirely up to you – though obviously your payment will depend on what you decide. The basic *structure* of the tree will remain the same from attempt to attempt, in the sense that there will always be a decision node, then a chance node, then a decision node, then a chance node and then a payoff node, in each attempt. Moreover, Nature will always behave completely randomly. **The one thing that will differ from attempt to attempt is the set of payoffs. You should therefore carefully check the set of payoffs on each attempt.**

Your Payment for Participating in the Experiment

As we have already remarked, you and the other person will be allowed several attempts at the tree. The precise number of attempts will be told to you when you start the experiment, and you will be reminded throughout of how many attempts you have done and how many remain to be done. On each attempt there will be a *payoff*, denominated in money. Your payment for the experiment will be a randomly chosen one of these payoffs. For example, suppose you are allowed 5 attempts at the tree. There will be 5 payoffs – one for each attempt. At the end of the experiment, you will be invited to call over one of the experimenters. He or she will have 5 cards, numbered from 1 to 5. These cards will be shuffled and you will be invited to pick one of the cards (obviously without seeing the number written on it). The number on the card that you pick will be noted and you will be paid the payoff on that numbered attempt. The same procedure will be followed to determine the payment of the other player. As we said before, you have precisely the same interests as the other player. In no way are you in competition.

How the Experiment will Proceed

The experiment will begin with a PowerPoint presentation of these Instructions. Then you will turn to the experiment itself. The opening screen displays the **EXEC** logo. When you are told to start you should click on the **EXEC** logo. You will then be told how many attempts at the tree you will be allowed. The decision tree will then be displayed. You should study this carefully, and particularly the various possible end (payoff) nodes. You will end up at one of these payoff nodes in any one attempt. You and the other player will then be invited to work through the tree, starting at the left-hand node, which is a decision node. At the first decision node, Player 1 will be asked to indicate whether he or she wants to move Up or Down and then Player 1 will be asked to confirm the decision by clicking on the button “Click here to confirm”; that decision will then be implemented, with the part of the tree that the decision has excluded turning grey to indicate that that part is no longer available. At the second decision node, Player 2 will be asked to indicate whether he or she wants to move Up or Down and then Player 2 will be asked to confirm the decision by clicking on the button “Click here to confirm”; that decision will then be implemented, with the part of the tree that the decision has excluded turning grey to indicate that that part is no longer available. At each chance node, you will be asked to get Nature to move by clicking on the button “Click here to get Nature to move”; you will then be told the move by Nature, and it will be implemented, with the part of the tree that Nature’s move has excluded turning grey to indicate that it is no longer available. After the second and final move by Nature, you will see that only one end (payoff) node remains available. This is the payoff for that attempt.

The end of the experiment

After you have completed all the attempts, the **EXEC** logo will once again be displayed, along with a message informing you that the experiment is over. The message will also list the payoffs on the various attempts. At this point, you should call over one of the experimenters. He or she will then carry out the procedure described above for determining your payment for the experiment. He or she will ask you to complete a brief questionnaire and will pay you your payment. You will be asked to sign a receipt for the payment.

Other

If there is any aspect of these instructions about which you are not clear, please ask the Experimenter. It is clearly in your interests to understand these instructions as fully as possible. Please also feel free to call the Experimenter at any time.

THANK YOU FOR YOUR PARTICIPATION