**Fairness is flexible[[1]](#footnote-1)\***

Subrato Banerjee[[2]](#footnote-2)† Priyanka Kothari[[3]](#footnote-3)‡

Prabal Roy Chowdhury[[4]](#footnote-4)+

Preliminary version – please do not quote

**Abstract**

While several allocation rules known in the cooperative bargaining literature, implicitly allow for various notions of fairness, there is no consensus about which notion of fairness exactly prevails in a given contextual environment involving a bargain. We look at three broad classes of fairness concepts and provide useful insights about which fairness notion to expect in a given scenario. We generate a unique dataset through our experiment involving dialogue-based bargaining and show that the size of the divisible pie itself provides strong hints about which fairness solution to expect. Additionally, we propose a new allocation rule that unifies the existing notions of fairness known in the literature, and performs better in terms of the predictive capacity to explain observed experimental data.

**Keywords:** fairness, cooperative bargaining, experiment

**JEL classifications:** C91, C70, D63, D64

**1. Introduction**

Ken Binmore (1994, 1998) argues that *fairness* is nature’s solution to the allocation problem of limited resources. The problem of resource allocation is two-fold: the first level addresses on ways to achieve (higher) efficiency (i.e. the movement from lower to higher payoff frontiers – a class of folk theorems can guarantee the sustainability of the higher frontiers); and the second level addresses the problem of picking an allocation among a set of competing allocations that are efficient. The focus of this paper is on the second level that has witnessed contributions in collective decision making in the form of bargaining problems (e.g. Nash) and those that involve the aggregation of individual preferences (e.g. Arrow), among other approaches to collective decision making that aim to achieve outcomes deemed apt by each consequential agent.

Fairness is often a crucial starting point to the development of such approaches. For example, implicit notions of fairness are embedded in Nash’s (1950) *axiom of symmetry*, and Arrow’s *axiom of non-dictatorship*. Fairness, as a key requirement, however, faces a central problem – there is no unique way to define fairness. Consequently, notions of fairness are not devoid of context. In this paper, we address this central problem by unifying three classes of fairness solutions in the spirit of Moulin (2003).

We first present an experiment, in which each treatment uniquely corresponds to exactly one of the three families of fairness solutions that is deemed most suitable. In other words, we explicitly show that in one treatment, one family of fairness solutions is the most suitable, in a second treatment, a second family of fairness solutions is the most suitable and so on. Therefore, each family of fairness solutions has a predictive capacity that is restricted to only, and exactly one treatment. We then propose a solution concept that unifies all the three fairness solutions, with the capacity to predict the outcomes in *all* the treatment groups.

As a first step, we will establish that the pie-size (the only element of change between our treatments) is itself a good indicator of which fairness solution concept to adopt. In this sense, our study is the most closely related to the research of List and Cherry (2008); and Andersen et al (2011), where it is shown that the monies transferred by the more consequential subjects respond less-than-proportionately to the stakes in hand. For example, Andersen et al (2011) show that as the pie-size increases, the proportional/relative offers made by the proposers of an ultimatum game diminish. This result can be explained by Rabin’s (1993) stylized requirement that the willingness (of the responder) to punish (by rejecting the offer) should diminish with higher stakes.

Fairness has important implications on the question of allocation of resources. For example, Fehr and Schmidt (2003) argue that many people are strongly motivated by concerns for fairness and reciprocity - not just material self interest. Our research is also closely related to Birkeland and Tungodden (2014), who show that the bargaining outcome is sensitive to the fairness motivation of the two individuals – disagreement on what a fair outcome is, may result in a disagreement (i.e. a loss of efficiency). Therefore, even if an agent does not feel strongly about fairness considerations, he may want to make higher offers to mitigation the chances of rejection by another agent who is known to value fairness strongly (Carpenter, 2003).

The task of unifying fairness concepts is challenging because it is well recognized that fairness perceptions frequently respond to changes in strategic environments (Schmitt, 2004). This malleability of ideals makes it possible for agents to (unknowingly) have self-serving biases in the idea of fairness (Babcock and Loewenstein, 1997). However, when notions of fairness are well-defined, any deviation(s) from the same often trigger feelings of shame and guilt for the deviating agents. These notions of fairness can be so powerful that if an agent is known to treat other interacting agents in a fair manner, then it is an immediate guarantee of loyalty and reciprocated fairness for this agent from the receivers of fair treatment (Chiu et al, 2009).

In conclusion, fairness is a key to pro-sociality (Henrich et al, 2010; Charness and Rabin, 2002), and is a driver of societal and institutional progress (Janssen, 2000), and can even shape regulatory stance (Banerjee, 2015). Therefore, we can consequently benefit from a unifying fairness ideal, in which many contextual ideas of fairness are nested.

**2. The theoretical structure**

*2.1. The formulation*

Two individuals *X* and *Y* (both from the same homogenous population) have the following two options.

Option 1: Individually earn *d(x)* and *d(y)*, respectively.

Option 2: Cooperate and generate a pie of size *z > d(x) + d(y)*, and share the same. Their respective shares are x and y (both non-negative), so that *x + y = z*.

In the event Option 2 is chosen, Moulin (2003) offers the following three classes of solutions (the last one is an intermediate between the first two extremes).

1. *Uniform Gains (UG): X* and *Y* share *z* equally – i.e. *x = y = z/2*.

2. *Proportional Gains (PG): X* and *Y* share *z* in proportion to their individual earnings

– i.e. *x/y = d(x)/d(y)*.

3. *Equal Surplus (ES): X* and *Y* share *z*, such that the gains from cooperation are matched

– i.e. *x – d(x) = y – d(y)*.

It is clear that when *d(x) = d(y)*, all the three solution concepts yield the same result. The blur between fairness ideals occur when *d(x)* and *d(y)* are different.

*2.2. A discussion*

In what follows, without loss of generality, we assume that *d(y) > d(x).* Now each of the three solution concepts can be thought of as a fair way to distribute *z*. For example, fixing *d(x) = 50, d(y) = 100,* and *z = 300*, will give us *(x = 150, y = 150)* under the *Uniform Gains* (*UG*) protocol; *(x = 100, y = 200)* under the *Proportional Gains (PG)* protocol, and *(x = 125, y = 175)* under the *Equal Surplus (ES)* protocol. It is clear that the *ES* allocation rules will always remain somewhere midway between the *UG* and the *PG* protocols for any value of *z*, *d(x)*, and *d(y)*.

The *Uniform Gains* protocol is theegalitarian solution as in Thomson, 1994, is the first extreme, where the differences between *X* and *Y*, if any, are inconsequential in terms of the final solution. For instance, the idea that all the rich and poor are equal in the eyes of the law is thought of a *fair* way to disseminate justice. The *Uniform Gains* solution may however, be questionable for it completely ignores (as it should) systematic differences between the agents in question. In our example, since *Y* can individually earn twice that of *X,* (i.e., clearly *d(y) = 100 = 2d(x) = 50*)then, *Y* may feel entitled to a higher share in *z*, since *Y* is (say) more efficient than *X*. This is true of the world we live in – Cardenas and Carpenter (2008), for example, point out that the perception of how deserving recipients of ultimatum games are, is a strong predictor of altruism. These interpretations are consistent with Aristotle’s idea of fairness which should be proportional to some measure of agents’ need, ability, effort and status. Thus, it is now fit to discuss the second extreme below.

*Proportional Gains* requires that the agents share the pie in proportion to their perceived individual capacities (in this case, 2:1), and has appealed to theorists who have modeled the same with axiomatic formulations. Kalai and Smorodinsky (1975) for instance, propose an allocation rule where the agents should share the pie in proportion to the maximum each could get in the absence of the other. The Equal-Area solution is also an allocation rule that predicts outcomes very close to the Kalai-Smorodinsky solution. Finally, there is a last class of solutions that are intermediate cases of the *UG* and the *PG* allocation rules. We discuss them now.

The most famous example of the *Equal Surplus* allocation rule is the Nash bargaining (Nash, 1950) solution, which maximizes *(x – d(x))(y – d(y))* with respect to *x* and *y* subject to the constraint: *x + y = z,* and leads to a first order condition: *x – d(x) = y – d(y)*, which is, in fact, the very requirement of the *ES* protocol. These solutions can also be perceived to be fair since there is a sense of equality in gains.

In short, all the classes of fairness rules require a sense of equality. Under the *UG* protocol, it is the equality of the *shares* (of the total pie-size); under the *PG* protocol, it is the equality of *proportions* (between the outcomes of agreement and disagreement); and it is the equality of *gains* (from cooperation – i.e. the transition from disagreement to agreement).

*2.3. Testable hypotheses*

We now set up a regression function that models the expected share of the high-capacity agent conditional on the pie size as follows:

*E(y|z) = α + βz (1)*

will generate three testable hypotheses based on the solution concepts we would want to test. For *d(x) = 50* and *d(y) = 100*, we are interested in the following testable hypotheses.

1. *Hypothesis UG:* If the subjects choose to share as per the *UG* rule, then formally, the testable hypothesis will be

*α = 0* and *β = ½*

2. *Hypothesis PG:* If the subjects choose to share as per the *PG* rule, then formally, the testable hypothesis will be

*α = 0* and *β = 2/3*

3. *Hypothesis PG:* If the subjects choose to share as per the *ES* rule, then formally, the testable hypothesis will be

*α = 25* and *β = ½*

We are now in a position to describe our experiment to disentangle one fairness solution concept from another.

**3. The experiment**

*3.1. An overview*

A total of 100 subjects (MBA students) from the School of Management, Manipal University, and 66 from the Indian Institute of Management, Indore participated in the experiment. The subjects were randomly assigned to one of three treatments, after which they took a test. After the test, each treatment group gets divided into two sub-groups of top half and bottom half performers – that is, the tests are graded and ranked according to the subjects’ performances, and then split into a top-half group and a bottom-half group in each treatment. Now, in each treatment, each subject among the top half performers is randomly paired with a subject among the bottom half performers for the purpose of bargaining. Now we describe the treatments.

*Treatment 180 (T180):* In this treatment, each subject from the top half (*Y*) is paired with each subject in the bottom half (*X*) and each pair formed of individuals *X* and *Y* are asked to split INR 180 (= *z*) among themselves. They are given a time period of ten minutes to reach an agreement, failing which, the outcome is treated as a disagreement, in which case the high-ranker in each pair is given INR 100 (= *d(y)*), and the low ranker is given INR 50 (= *d(x)*). Since, in this treatment, the size of the pie is only marginally higher than the sum of the disagreement payoffs (*d(x) + d(y) =* INR 150), we expect *X* and *Y* to share the pie-size of INR 180 according to the *PG* rule. This is because, the other extreme of *UG* will require that each individual gets INR 90, leading to a loss from cooperation for the high-ranked individual. Thus, for marginal gains over the sum of disagreement payoffs, the chosen allocation rule must replicate the ratio of the disagreement payoffs as closely as possible.

*Treatment 300 (T300)*: In this treatment, *X* and *Y* are asked to split a sum of INR 300 (= *z*) between themselves. Everything else remains the same. In this treatment, we allow for the possibility of simultaneously observing agreement as per all the three allocation rules.

*Treatment 600 (T600):* In this treatment, *X* and *Y* are asked to split a sum of INR 600 (= *z*) between themselves. Everything else remains the same. In this treatment, since the gains from cooperation are the largest (*z – d(x) – d(y) =* INR 450), we expect the agents *X* and *Y* to disregard their individual differences (which together, blur in front of the significantly higher gains) and gravitate towards equality required by the *UG* solution.

*3.2. Further details*

In each treatment, bargaining happened between *X* and *Y* over Skype with rank revealing IDs such as Rank.001, Rank.002 and so on. This helped in preserving anonymity, which is desirable because the knowledge of who each subject was paired with would mitigate the effect of the test. Further, it retained a key feature of real-life bargaining and negotiation processes – *dialogue*. In the real world, economic agents give away apt reactions through either their vocal tone or facial expressions when they are pleased or displeased with the direction of negotiations. Our subjects were found to frequently use apt emoticons when they felt that the bargains suggested by their partners were fair or unfair. The process of communication used text-chat instead of voice-chat to mitigate the possibility of any identification, since the subjects came from a homogeneous population (i.e. the same institution) and were likely to be friends.

Finally, the test was a compilation of 20 extremely difficult questions for which, a time limit of only 15 minutes was given. Each question was followed by four possible answers of which, only one was correct. There was no negative marking and the instructions explicitly required the subjects to maximize their total score of right answers. The extreme difficulty level ensured that the subjects were forced to resort to random ticking of the answers. Thus, effectively, each question had a one-fourth probability of being answered correctly. Clearly, on an average, therefore, we should expect one-fourth of the given questions to be correctly answered. We see that the students got an average score of 4.96 out of 20, which is not significantly different from what is expected. Therefore, we are confident that the ranking on the basis of the test is as good as random. Thus, having the actual rank of *Y* as a potential determinant in regression (1) is least likely to be correlated with unobserved ability.

**4. Descriptive statistics and results**

*4.1. A combined analysis of all the treatments*

**Table 1. Share of *Y* as a determinant of the pie size *z***

|  |  |  |
| --- | --- | --- |
| Dependent variable: | (1) | (2) |
| Share of *Y* | OLS | OLS |
|  | |  |  |
| Pie-Size (*z*) | | 0.497\*\*\* | 0.499\*\*\* |
|  | | (0.014) | (0.013) |
| Absolute Rank Difference | |  | 1.476\*\*\* |
|  | |  | (0.273) |
| Constant | | 23.459\*\*\* | 3.438 |
|  | | (3.851) | (6.085) |
| Observations | | 83 | 83 |
| R-squared | | 0.85 | 0.86 |
|  | |  |  |

Notes: \*\*\*, \*\*, and \* mark out significance at 1%, 5% and 10%

Table 1 shows the regression results for equation (1). Panel (1) shows the raw results from regression (1). We immediately reject hypotheses *UG* and *PG* because of the constant term which is significantly different from zero. Clearly therefore, the *UG* and the *PG* allocation rules do not explain the observed bargaining outcomes in all the treatments. The *ES* solution is not rejected immediately in column (1), but when we add the absolute rank difference (the number of ranks the high-ranked subject was ahead of the low-ranked subject), to regression (1) as shown in panel (2), we see reasons to reject the *ES* solution as well.

*4.2. An analysis of individual treatments*

Table 2 compares the observed shares in each treatment with the expected shares under each hypotheses.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 2.**  **(1)** | **N**  **(2)** | **Mean**  **(3)** | **95% CI**  **(4)** | **PG**  **(5)** | **ES**  **(6)** | **UG**  **(7)** | **Our**  **Allocation**  **Rule** |
| **T180** | 27 | 0.639  (0.009) | 0.620 – 0.658 | 0.67  ⌧ | 0.639  🗹 | 0.500  ⌧ | 0.621  🗹 |
| **T300** | 29 | 0.567  (0.007) | 0.552 – 0.582 | 0.67  ⌧ | 0.583  ⌧ | 0.500  ⌧ | 0.557  🗹 |
| **T600** | 27 | 0.538  (0.009) | 0.519 – 0.556 | 0.67  ⌧ | 0.541  🗹 | 0.500  ⌧ | 0.523  🗹 |

Column (1) above enlists the treatments, and in column (2), we report the number of pairs in each treatment. Column (3) reports the mean share of the high ranked individual *Y* observed in each of the treatments followed by the standard errors in the parentheses, which in turn are used for the confidence intervals in column (4). Columns (5), (6) and (7) show the expected share for the high ranked subject *Y* in each treatment under the *PG, ES,* and the *UG* allocation rules, followed by a ⌧ or a 🗹, depending on whether observations in the relevant treatment groups are inconsistent or consistent with the allocation rules in question (i.e. the 95% confidence intervals around the observed mean in the given treatment contains the predicted value of the said allocation rule). For example, the entry of 0.67 under the *PG* rule in column (5), for the treatment T300 means that 67% of the pie should go to agent *Y* if the *PG* rule were followed. However, this value is clearly outside the 95% confidence intervals (shown in column 4) around the observed mean share of T300. In other words, this value of 0.67 is significantly different from the observed average of 0.57 in T300. Thus, we reject the hypothesis that the *PG* rule explains the observed shares in T300, and represent the same with a ⌧ sign underneath the expected value under the *PG* rule. Since each of the columns (5), (6) and (7), has at least one ⌧, it means that all of the observed experimental data is not being explained by any of the rules.

*4.3. An explanation of the results*

In the last column of table 2, we provide our allocation rule which is not rejected by any of the observed treatment groups. If we define ‘surplus’ *s* to be the difference between a given pie size and the sum of individual earning capacities, i.e. *s = z – [d(x) + d(y)]*, then our allocation rule is given as follows:

*x/y = [s + d(x)]/[s + d(y)] (2)*

If the gains from cooperation (*s*) are low in relation to the disagreement payoffs, then the subjects will still tend to use the *PG* rule and share in proportion to their disagreement payoffs. However, if the gains from cooperation are so high that the effect of individual capacities blur away, then there will be a convergence toward equality. For example, what would happen if *s =* INR 10 million? More formally, the *PG* rule is attained such that

x/y =

and the *UG* rule is attained such that

x/y =

This is supported even by the experimental data – we see that the observed share of the high-raked individual gets closer to 50% as the pie size *z* (and therefore *s*) increases. This convergence to equality is faster than what the *ES* rule suggests.

**5. Conclusion**

We have addressed the frequently arising issue in the discipline of bargaining that what all factors can influence bargaining outcome through the channel of fairness consideration. In the experiment, it was observed that the amount of stakes involved may in itself provide useful hints on what is perceived as fair by the agents, as the proportion of disagreement payoff in the entire pie size decreases agent moves from choosing PG to UG to determine the final outcome. We also proposed a solution concept that unifies all the three solution concept just by varying the overall pie size that explains the observed pattern in the data.

**APPENDIX A**

**Test**

Instructions: You have 15 minutes to complete this test. There are 20 questions: Each question (marked 1, 2, 3, etc.) is immediately followed by four options (marked a, b, c, and d). Only one of the options correctly answers the associated question. Your task is to mark a tick on what you believe to be the correct answer and maximize your score. Each correct entry carries one point. There is no negative marking. You may begin. All the best.

Name:

Gender (M/F):

Course:

Please leave the following spaces blank.

Time:

Score:

Experimental Reference ID:

1. A truel is similar to a duel, except that there are three participants rather than two. One morning Mr. Black, Mr. Grey, and Mr. White decide to resolve a conflict by truelling with pistols until only one of them survives. Mr. Black is the worst shot, hitting his target on average only one time in three. Mr. Grey is a better shot hitting his target two times out of three. Mr. White is the best shot hitting his target every time. To make the truel fairer, Mr. Black is allowed to shoot first, followed by Mr. Grey (if he is still alive), followed by Mr. White (if he is still alive) and round again (and again) until only one of them survives. Where should Mr. Black aim his first shot?

(a) He should aim at Mr. White

(b) He should aim at Mr. Grey

(c) He should shoot himself

(d) He should shoot in the air

2. Two urns contain the same total number of balls - each ball is either black or white, and these urns have different compositions of black and white balls. There is at least one ball of each color in each urn. From each urn, n (≥3) balls are drawn with replacement. We are interested in the number of drawings and the composition of black and white balls in the two urns, such that the probability that all the balls drawn from the first urn are white, is equal to, the probability that either all balls drawn from the second urn are white or all are black. Which of the following statements is true?

(a) This will never be possible

(b) Number of white balls in the first urn must be greater than the number of both white and black balls in the second urn

(c) Number of black balls in the second urn ≥ number of white balls in the first urn ≥ number of white balls in the second urn

(d) Number of white balls in the second urn ≥ number of white balls in the first urn ≥ number of black balls in the second urn

Answer the next two questions (3 and 4) based on the information in the following question:

3. If NK = {1,...,K}, then how many sets X={xi∈NK∗|i∈NK∗} solve the following problem when K∗>K∗>2?

maximize: [max(X)-min(X)]-[max(X\{max(X)})-min(X\{min(X)})]

(a) There exists only one unique set solving the above problem

(b) K∗ - K∗ sets

(c) There are exactly two sets that solve the above problem

(d) K∗ - K∗ + 1 sets

4. The maximum value in the above problem is

(a) K∗ - K∗ - 1

(b) K∗ - K∗

(c) K∗ - K∗ + 1

(d) K∗ - K∗ + 2

Answer the next three questions (5 to 7) based on the information in the following question:

5. Let the function f:(1,∞)↦(0,∞) satisfy the property f(xy)=f(x)+f(y); ∀x,y∈(1,∞), we look at the set of equations below

f(y)=f(2)+f(x)

yf(x)=xf(y)

the pair (x,y) that solves the above set of equations is

(a) not unique, there are infinitely many such pairs

(b) the information is insufficient to even determine if (x,y) is unique or not

(c) x = 2,y = 4

(d) unique, but there is insufficient information to arrive at the actual values of x and y

6. Now, alter the domain of the function f to [1,∞), and its range to [0,∞). Define a function

g : (-∞,∞)↦(0,∞)

which satisfies the property g(x + y)=g(x) g(y). The value of f(g(0)) + g(f(1)) always equals

(a) 0

(b) 0.5

(c) 1

(d) Can't be determined

7. Alter again the domain of f above to ℝ - {0} and its range to (-∞,∞). Consider the following statements.

Statement 1 : f((1/x)) = -f(-x)

Statement 2 : f(-1) = 0

Mark the correct option.

(a) Only Statement 1 is true

(b) Only Statement 2 is true

(c) Both the statements are true

(d) Neither of them is true

Answer the following two questions (8 and 9) based on the following information. Jack is captured by a tribe. Whether or not he gets to live is decided by the tribe members based on the outcome of the following exercise. There are 50 black and 50 white balls, which Jack must distribute between two identical and opaque boxes (that the tribe provides to him) in any way he wishes, but with the requirement that each ball must be put into one of the two boxes. The tribe then secretly allocates the balls among the two boxes as instructed by Jack and closes them before putting them in front of him. Jack gets to randomly pick a box before they blindfold him and make him draw a ball from it. If the ball is white, he survives, otherwise they execute him.

Answer the following two questions.

8. Jack's maximum probability of survival is

(a) 1/2

(b) 74/99

(c) 3/4

(d) 71/100

9. If Jack were offered five boxes instead of just two above, then his maximum probability of survival will

(a) definitely increase

(b) definitely decrease

(c) remain the same

(d) well ... can't say

10. Which of the following events is more likely than the others?

(a) Getting at least 1 six when 6 dice are rolled

(b) Getting at least 2 sixes when 12 dice are rolled

(c) Getting at least 3 sixes when 18 dice are rolled

(d) All the three events above are equally likely

11. A professor chooses two consecutive numbers from the following set {1, 2, 3, ... , 10}. A is told the first number and B, the other. The following conversation takes place:

A: I do not know your number.

B: Neither do I know your number.

A: Now I know.

In how many ways can the professor chose the number so that this exact conversation between A and B is possible?

(a) 1

(b) 5

(c) 2

(d) 4

12. The number of linear functions f : ℝ ↦ ℝ that satisfy the property f(x + f(x)) = x is

(a) 1

(b) 2

(c) 3

(d) 4

13. You want to find someone whose birthday matches yours. What is the least (expected) number of strangers whose birthdays you need to ask to have a (greater than) 50% chance of finding a match? (Assume a year of 365 days.)

(a) 23

(b) 183

(c) 253

(d) 364

14. Alice was first to arrive at a 98 seat theatre. She forgot her seat number and picks a random seat for herself. After this, every single person who get to the theatre sits on his seat if its available else chooses any available seat at random. Charles is last to enter the theatre and 97 seats were occupied. With what probability does he get to sit in his own seat?

(a) 1

(b) 1/2

(c) 1/3

(d) 1/4

15. Shuffle an ordinary deck of 52 playing cards containing four aces. Then turn up cards from the top until the first ace appears. On the average, how many cards are required to produce the first ace?

(a) 10.6

(b) 9.6

(c) 13.0

(d) 13.4

16. If a stick is broken in two at random, what is the average (expected) ratio of the length of the smaller piece to the larger?

(a) 0.333

(b) 0.386

(c) 0.301

(d) 0.441

17. A player tosses a coin from a distance of about five feet onto the surface of a table ruled in one-inch squares. If the coin (3/4 inches in diameter) falls entirely inside a square, the player wins a holiday package; otherwise he loses. If the penny lands on the table, what is his probability of winning?

(a) 1/2

(b) 1/4

(c) 1/8

(d) 1/16

18. To encourage Bob's promising tennis career, his father offers him a prize if he wins (at least) two tennis sets in a row in a three-set series to be played with his father and a club champion alternately: father-champion-father or champion-father-champion according to Bob's choice. The champion is a better player than Bob's father. Which series should Bob choose (assume that the outcome of each game in a given series in independent of another)?

(a) father-champion-father

(b) champion-father-champion

(c) He will be indifferent between the two

(d) There is no definite answer

19. For any function f with f′ > 0, and f′′ < 0, the maximum value of f(x) f(1-x) is attained at

(a) the maximum of f[x(1 - x)]

(b) x = 1/2

(c) both (a) and (b) above

(d) Cannot be determined

20. A three-man jury has two members, each of whom independently has a probability p of making the correct decision and a third juror who flips a coin for each decision (majority rules). A one man jury has the probability p of making the correct decision. Which jury has the better probability of making the correct decision?

(a) Both of them are equally good

(b) The three-man jury is better than the one-man jury

(c) The one-man jury is better than the three-man jury

(d) There is no conclusive answer

**APPENDIX B**

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2. †Queensland University of Technology (Email: [subrato.banerjee@qut.edu.au](mailto:subrato.banerjee@qut.edu.au)); Honorary Fellow (Australia India Institute), University of Melbourne (Email: [subrato.banerjee@unimelb.edu.au](mailto:subrato.banerjee@unimelb.edu.au)). [↑](#footnote-ref-2)
3. ‡Indian Statistical Institute (Email: [priyanka12r@isid.ac.in](mailto:priyanka12r@isid.ac.in)). [↑](#footnote-ref-3)
4. +Indian Statistical Institute (Email: [prabalrc@isid.ac.in](mailto:prabalrc@isid.ac.in)). [↑](#footnote-ref-4)