"Isn't everyone like me?": On the presence of self-similarity in strategic interactions[*]

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Abstract

After playing the Chicken game against an anonymous random opponent, players report their beliefs about their opponent's action. It is argued that the reported beliefs are not consistent with the standard theory of rational choice, which predicts a negative correlation between a player's action in the Chicken game and the probability he assigns to his opponent choosing the same action. It is also argued that the reported beliefs are influenced by *self-similarity* considerations, whereby a player tends to think that other players behave similarly to him, and thus reports beliefs that gravitate toward his own action. Self-similarity considerations are stronger when players are asked about the distribution of actions in the population of potential opponents than when they are asked about their particular opponent.

1 Introduction

The standard theory of games assumes that in strategic interactions a player forms beliefs about his opponent's action, and best-responds according to those beliefs when choosing his own action. It is thus expected that the beliefs reported by a player after choosing his action will provide *strategic justification* for that action, in the sense that the action maximizes his payoff with respect to those beliefs. We propose that a player's ex-post beliefs are also influenced by *self-similarity* considerations, whereby a player tends to think that other players behave similarly to him, and thus reports beliefs that gravitate toward his own action.

Demonstrating the existence of self-similarity requires a game in which the predictions of self-similarity are different from those of strategic justification. One example is the Chicken game, a two-player symmetric game in which each player chooses either "Dove" or "Hawk" and his payoff depends on both his own action and that of his opponent as follows:

	Dove	Hawk
Dove	30, 30	20, 70
Hawk	70, 20	0, 0

A rational player should choose Dove if he believes that his opponent is sufficiently likely to choose Hawk, and should choose Hawk if he believes that his opponent is sufficiently likely to choose Dove. Thus, if a player's reported beliefs provide strategic justification for his action, then the proportion of players who choose Dove should *decrease* with the probability that players assign to their opponent choosing Dove. Our experimental results demonstrate that this prediction fails, and thus provide support for self-similarity.

Participants in the experiment were asked to play the Chicken game against an anonymous opponent who has been selected randomly from among several hundred participants. After choosing an action, participants were asked to report their beliefs in one of two frames: the "population" frame, in which players were asked to report their beliefs regarding the actions of all those who are playing the game, and the "opponent" frame, in which players were asked to report their beliefs regarding the action of their particular opponent.

Our first finding is that in both frames the proportion of players who choose Dove does not decrease with the probability that players assign to their opponent choosing Dove. In the population frame, the proportion of players choosing Dove even *increases* significantly with the probability assigned to Dove. Thus, an additional force is present in participants' belief formation. Based on the psychology literature on the false consensus effect in non-strategic decision making (see Ross, Greene & House (1977) for the original contribution

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and Marks and Miller (1987) for a survey), we conjecture that this additional force is self-similarity, i.e., the tendency of people to believe that other people behave similarly to them.

Support for this conjecture is obtained by comparing participants' reported beliefs in the two frames. Given the random assignment of participants to pairs, identical beliefs should be reported in both frames. If, however, self-similarity considerations are present in ex-post belief formation, it can be expected that the population frame will trigger self-similarity to a larger extent than the opponent frame. Our second finding is that participants' reported beliefs indeed place significantly more weight on a participant's own action in the population frame than in the opponent frame.

Note that Dawes, McTavish and Shaklee (1977) and Messé and Sivacek (1979) have already claimed that players have a tendency to believe that their opponent will choose the same action that they do. They base this claim on their findings for the Prisoner's Dilemma game (PD). However, in contrast to Chicken, this tendency in PD can be attributed to strategic justification rather than self-similarity. This is because a player in PD may perceive the payoff he obtains when he and his opponent cooperate as larger than when the player defects and his opponent cooperates. Thus, strategic justification and self-similarity may operate in the same direction in PD. Examining participants' responses in Chicken allows us to distinguish between the two forces.

2   Method

The didactic site http://gametheory.tau.ac.il served as the platform for the experiment. The participants (N=527) consisted of current and former students in a number of countries, most of whom had taken an undergraduate course in game theory. The participants had used the site previously, and agreed to participate in online survey experiments.

Participants were asked to play a game against an opponent who had been selected randomly from among several hundred participants. It was promised that one pair of players would be chosen randomly to receive their payoffs (in USD) according to the outcome of their game.

After choosing their action in the game, participants were asked to report their beliefs. They were randomly assigned to one of the following two frames:

(i) The "Population" frame: What are your beliefs regarding the distribution of choices among all those who play the game?
I believe that   % choose Dove and   % choose Hawk.

(ii) The "Opponent" frame: What are your beliefs regarding the choice of your opponent?

I assign a probability of ___ % to my opponent choosing Dove and ___ % to my opponent choosing Hawk.

3 Results and discussion

We omitted the 43 participants whose reported beliefs did not sum up to 100% in this task or in another unrelated task that appeared later in the questionnaire. We were left with 484 participants, 62.9% of whom chose Dove and 37.1% of whom chose Hawk.

3.1 Population frame

Table 1 summarizes the reported beliefs in the population frame for the choosers of Dove and for the choosers of Hawk. The choosers of Dove tend to believe that other players will choose Dove and the choosers of Hawk tend to believe that other players will choose Hawk.

	Population frame	
Action in game	Dove (N=162)	Hawk (N=82)
Average belief Dove	59.9% (1.7)	43.3% (2.6)
Average belief Hawk	40.1%	56.7%
Median belief in Dove	67%	50%

Table 1: Reported beliefs in population frame

Figure 1 provides a finer description of the data by means of the CDFs of the probability assigned to Dove by choosers of Dove and by choosers of Hawk. For choosers of Dove, we plot for every $0 \leq x \leq 100$ the proportion of participants who assigned a belief weakly less than x to Dove, and correspondingly for choosers of Hawk.

The CDFs differ significantly. (The Kolmogorov–Smirnov test statistic for the equality of the CDFs is 0.35 ($p < 0.001$).) Furthermore, the CDF for the choosers of Dove first-order stochastically dominates the CDF for the choosers of Hawk, i.e., choosers of Dove assign higher likelihoods to others choosing Dove than do choosers of Hawk.

Table 2 presents the data from a different perspective. For the 78% of the participants whose reported beliefs are a multiple of 10, the table reports the proportion of participants choosing Dove as a function of their beliefs. The table also includes the predictions of a logistic regression of "choosing Dove" on the "belief that others choose Dove." (The regression predicts that Logit(probability of choosing dove) = -0.959 +3.17(belief in dove), OR = 23.78, $p < 0.001$.) Clearly, the proportion of participants who choose Dove increases
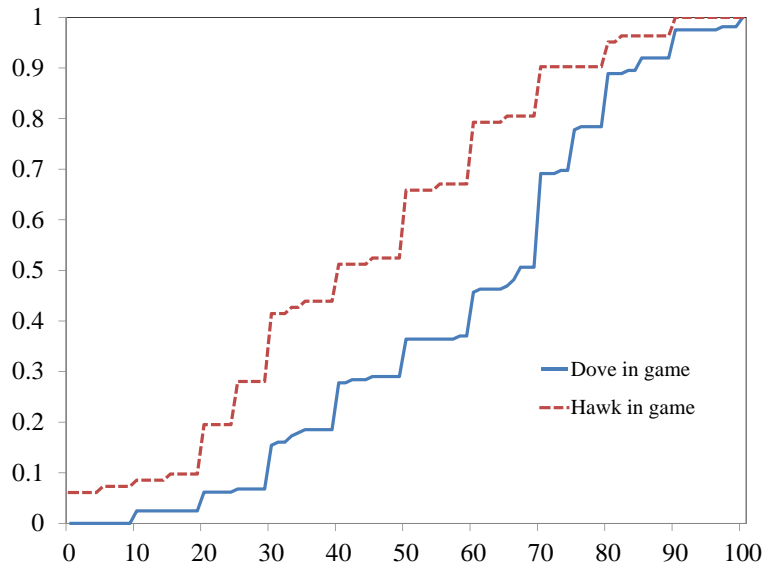
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Figure 1: CDFs of probability assigned to Dove in population frame

with the belief on Dove.

Belief	0	10	20	30	40	50	60	70	80	90	100
N=	5	5	14	25	21	23	24	38	21	12	3
Actual % choosing Dove	0	80	43	56	71	52	58	79	81	75	100
Regression prediction of % choosing Dove	27	34	42	50	58	65	72	78	83	87	90

Table 2: Proportion choosing Dove whose reported beliefs are multiples of 10

Discussion. Two patterns emerge in the population frame. First, players tend to believe that others behave similarly to them (table 1 and figure 1). Second, the tendency to choose Dove increases with the probability that players assign to others choosing Dove (table 2).

We now show that strategic justification alone cannot explain these patterns. Let d denote the probability that a player assigns to his opponent choosing Dove. A player compares the lottery $L(Dove) = (d)[30] + (1-d)[20]$ which he obtains by choosing Dove with the lottery $L(Hawk) = (d)[70] + (1-d)[0]$ which he obtains by choosing Hawk. The belief d provides strategic justification for the player's action if that action corresponds to the player's preferred lottery. Assume that a player's beliefs are independent of his preferences over lotteries. Then, expected utility predicts that if two players have the same preferences and the one with the higher d chooses Dove, then the one with the lower d also chooses Dove. This "single crossing property" is valid for any theory of choice under uncertainty that has a measure representation (see Segal (1993)) and, in particular, any

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rank-dependent model.

Thus, strategic justification predicts that the larger d the smaller the proportion of players who play Dove. Table 2 and the logistic regression indicate that the opposite is true: the larger the weight players assign to their opponent playing Dove, the more likely they are to play Dove. This constitutes evidence for the presence of self-similarity in ex-post belief formation.

3.2 Opponent frame

In the opponent frame, participants were asked to report their beliefs regarding the choice of their specific opponent. The reported beliefs should be identical to those reported in the population frame since a player's opponent is randomly selected from among the several hundred participants in the experiment and players are informed about that. We conjectured, however, that asking a player about his opponent rather than about all the players would trigger strategic justification to a greater extent and hence attenuate the effect of self-similarity.

Table 3 and figure 2 illustrate that the beliefs of choosers of Dove and choosers of Hawk in the opponent frame are very similar. (The Kolmogorov–Smirnov test statistic for the equality of the CDFs in Diagram 2 is 0.11 ($p = 0.45$).) The similarity of the CDFs implies that the proportion of players choosing Dove does not increase with the weight d in contrast to the predictions of strategic justification. That is, self-similarity is also present in the opponent frame.

	Opponent frame	
Action in game	Dove (N=142)	Hawk (N=97)
Average belief Dove	51.8% (1.9)	50.5% (2.3)
Median belief in Dove	50%	50%
Average belief Hawk	48.2%	49.5%

Table 3: Reported beliefs in opponent frame

Discussion: Comparing the two frames. Figure 3 illustrates the contrast between the reported beliefs in the opponent frame and in the population frame. The figure compares the CDFs of the probability assigned to Dove in the two frames for choosers of Dove (on the left) and the CDFs of the probability assigned to Hawk for choosers of Hawk (on the right). The comparison clearly shows that participants place more weight on their own action in the population frame than in the opponent frame. (The K–S test statistic for the equality of the CDFs in the left figure is 0.2 ($p < 0.005$) and in the right figure is 0.18
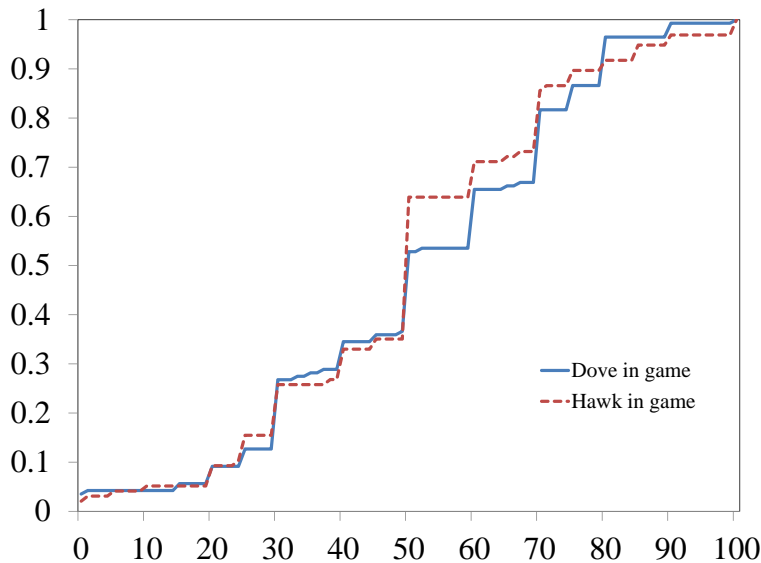
Figure 2: CDFs of probability assigned to Dove in opponent frame

($p = 0.09$).) Thus, the degree of self-similarity in reported beliefs is larger in the population frame than in the opponent frame.

4 Conclusion

The results of the experiment demonstrate that self-similarity considerations are present in ex-post belief formation in the Chicken game. Moreover, the effect of self-similarity on the reported beliefs depends on the framing of the belief elicitation question: it is stronger when players are asked about the distribution of choices in the population of potential opponents than if they are asked about their particular opponent.

The difference in reported beliefs between the two frames is relevant for the assessment of belief elicitation techniques in experimental game theory. It is a common experimental practice to refrain from asking players about their beliefs prior to playing a game due to the concern that this will affect their deliberation process and choice in the game (for a different view, see Costa-Gomes and Weizsäcker (2008)). Players are therefore often asked to report their beliefs after playing the game. Our results indicate that ex-post reported beliefs may crucially depend on how the belief elicitation question is framed.
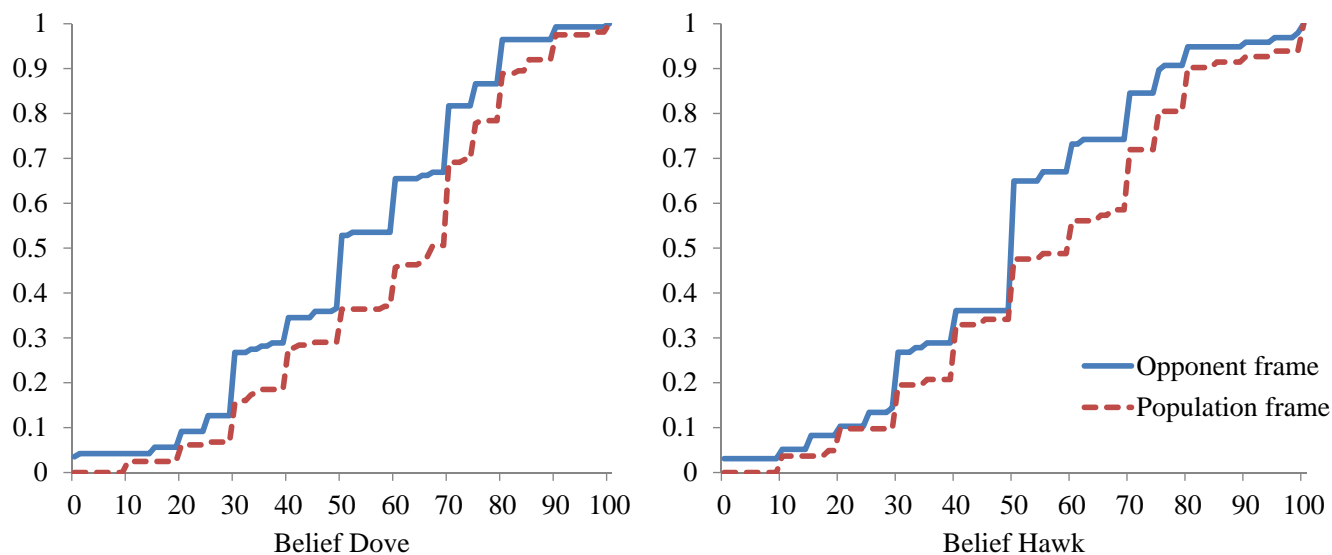
Figure 3: CDFs in population and opponent frame. Left: CDFs of Dove for choosers of Dove. Right: CDFs of Hawk for choosers of Hawk.

5   References

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