The Beauty Contest On Amazon Mechanical Turk: Going Further Into The Field

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Abstract

We examine the process of reasoning among 296 subjects playing the iterated beauty contest game on Amazon Mechanical Turk. Our findings are substantially different from the behaviors observed in laboratory and newspaper experiments reported in the literature. In general, we do not find any strong evidence in favor of higher-order reasoning in the first round as well as in the following iterations of the game, which puts into question the presence of any strategic thinking among the vast majority of subjects.

Keywords: Beauty Contest, Mechanical Turk, Iterated best response, Higher-order reasoning

JEL Classification: C72, C73

1. Introduction

The so-called *beauty contest game* has been introduced by Keynes [22] to explain how expectations about the beliefs of other agents play a crucial role in financial

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markets. The label “beauty contest” nowadays encompasses a variety of different experimental games having in common the key role played by the subjects’ ability to think about each others thought processes, e.g. their ‘theory of mind’ and depth of strategic reasoning [24, 3, 17, 19, 10, 26, 16].

The most well-known example, due to Moulin [23], is the following: each player has to choose a number in the interval [0, 100]; the players who are the closest to $2/3$ of the average of all chosen numbers evenly split a fixed positive monetary amount. The only equilibrium of this game is when all players choose the lowest number, zero. However, choosing zero may not win the game: if for instance there are more than two players in the game, and a player believes that all other players are going to pick a number sufficiently greater than zero, then zero is not a best response.

The beauty contest has been extensively tested in experiments to study the players’ depth of strategic reasoning – i.e., the number of steps in an unobservable process of reasoning about each other intended to explain the behavior of agents in interactive decision making [24, 3, 17, 19, 10]. The bulk of classic experiments have been carried out as lab experiments with small- and medium-sized groups of university students (e.g. Nagel [24], Ho et al. [19], see also Camerer et al. [10] and Nagel [25] for an overview), or as single-shot large-scale newspaper contests [3].

Loosely, the idea is that the higher the level in the depth of reasoning, the lower the chosen number will be [9]. A player with depth of reasoning of level zero simply chooses a random or salient number between 0 and 100 in the first round. Two different solution concepts have been proposed to capture the higher-order reasoning of players. According to the first, called *degenerate*[1] *iterated best response reasoning* (IBRd) and used for instance in Nagel [24] and Bosch-Doménech et al. [3], a player of level one is supposed to best respond to the belief that his or her opponents are of level zero. Therefore, a player of level one would choose (a number close to) $50 \cdot 2/3 = 33.3$, which is the best response to the belief that the other players choose at random from a symmetric distribution around 50. By iterating the same reasoning once more, a player of level two would choose (a number close to) $50 \cdot (2/3)^2 = 22.2$. By repeating this reasoning infinitely many times, a player with infinite depth chooses the minimum, zero.

An alternative solution concept for capturing the higher-order reasoning of players, used e.g. in Ho et al. [19], is the iterated elimination of dominated strategies. A player of level one accordingly chooses only numbers from the interval $[0, 2/3 \cdot 100]$, because any number in the interval $(2/3 \cdot 100, 100]$ is dominated by $2/3 \cdot 100 = 66.6$. By iterating the same reasoning, a player of level two, chooses only numbers in the interval $[0, (2/3)^2 \cdot 100]$, and the process converges again to zero as the levels of depth go to infinity. Infinite iterations of either solution concept thus lead to the sole equilibrium of the game.

Classic papers on the beauty contest report findings of higher-order reasoning and classify most subjects between level one and level two of depth of reasoning [24, 19, 16, 26, 32, 3]. A high number of guesses in the proximity of the numbers 33 and 22 in the first round are found by Nagel [24], Selten and Nagel [32] and interpreted as revealing the presence of IBRd as well as of one or two levels of higher-order reasoning by the majority of subjects. This finding is later confirmed

[1] The term "degenerate" comes form the assumption that each agent assigns probability 1 to the other players being of exactly one reasoning level lower than herself.

by a survey of the results from laboratory, classroom, and also newspaper experiments on the beauty contest in Bosch-Doménech et al. [3], where it is stated in terms of the following two facts:

Fact 1. *All experiments analyzed result in frequency spikes at number choices 33.33 and 22.22 and also [...] at equilibrium. Furthermore, in all experiments the modal reasoning process described in the comments is IBRd. (p. 1697)*

Fact 2. *A majority (64 percent) of comments show subjects using an IBRd argument, of which 15 percentage points correspond to Level 0 (random choice). (p. 1692)*

The survey in Bosch-Doménech et al. [3] contains also a relevant contribution about the so-called assumption of *parallelism* between the lab and the field. By finding similar results between lab experiments and field experiments performed on three different newspapers, the authors conclude that the behavioral patterns observed in laboratory experiments with sociodemographically biased samples (university students in most cases) still hold true in field experiments on newspapers. The same behavioral patterns found in the laboratory thus apply to the population at large, and the assumption of parallelism between the lab and the field is supported.

Fact 3. *The fact that three experiments involving thousands of subjects, run in different countries, for different newspapers, catering to different populations, yield very similar results is a clear indication that we are observing a pattern of behavior that must be quite common. In addition, this pattern is replicated in lab experiments with subject pools of undergraduate, graduate students, and economists.*

This indicates that the "parallelism" assumption between lab and field has been upheld. (p. 1697)

The experiments we performed on Amazon Mechanical Turk (AMT) seem to contradict, rather than support, such conclusions on both higher-order reasoning and the parallelism between the field and the lab. As for the behavior in the first round, no spikes corresponding to possible iterations of higher-order reasoning are found. Rather, a symmetric distribution of guesses around 50 is observed.

As for subsequent repetitions of the beauty contest, subjects are commonly supposed to adjust their behavior based on both strategic reasoning and the observation of previous guesses and averages. On this point, our observations from AMT are incompatible with the combination of higher-order reasoning and learning processes taking the mean (or two-thirds of the mean) of the previous round as reference point for the players' strategic reasoning, as most often the subjects choose numbers greater than the target (two-thirds of the mean) of the previous round, while observing a decreasing sequence of means and targets over subsequent rounds. This suggests that higher-order reasoning may be missing in subsequent repetitions of the beauty contest as well.

While our original interest was focused on a variation of the classic beauty contest, we unexpectedly observed substantial differences in the behaviors of the subjects in the control group playing the standard beauty contest relative to the findings reported in the literature. Since the majority of subjects on AMT may be less biased towards or trained in puzzle-solving and rational thinking than university students and economists, we decided to contact the authors of previous experiments on the beauty contest to first compare our results with theirs, and to analyze our variant of the beauty contest in a separate paper. We are deeply grateful to Prof. Nagel for sharing her data with us.

The paper is organized as follows. After describing our experiments in Section 2, the findings are analyzed in detail in Section 3, which is divided into two parts corresponding to the first round (Subsection 3.1) and to subsequent rounds (Subsection 3.2). Section 4 discusses the assumption of parallelism in the light of our results, and Section 5 concludes.

2. Method

We designed a set of iterated beauty contests on Amazon Mechanical Turk, an online labor market and crowdsourcing platform which has been shown to be reliable, replicable, and significantly more diverse than typical American college samples [7, 14, 20, 27]. A total of 296 participants were randomly spilt into 50 two-player groups, 23 four-player groups and 13 eight-player groups. After the groups were formed, players were introduced to the game in the following way:

> Instructions: You are in a group of 2 [4 or 8, respectively] players. In each round players will be asked to choose a number between 0 and 100. The winner will be the player whose number is closest to $2/3$ of the average of all chosen numbers. The game has 8 rounds. Payoffs: Each player will receive a participation fee of $2 after finishing the game. In addition, the winner in each round will get a bonus of $0.25 [$0.5 or $1, respectively]. If there is more than one winner the bonus is split. Examples: if you choose 30 as the number closest to $2/3$ of the average and win the round, you will receive $0.25 [$0.5 or $1, respectively]. If you and another player guess 20 and win, you will win half of the bonus.

The payoff structure ensures that players receive on average the same bonus across different group sizes and are unlikely to quit the game prematurely, because the overall bonus after eight rounds potentially could become substantially larger than the flat participantion fee of $2. After each round, each player's guess was recorded, and players were shown the winning guess, the full list of previous guesses by all players, the averages in all previous rounds, as well as the $2/3$ of those averages.[2] After round 8 players were thanked and asked about the strategy they used when playing the game, which provided valuable information on the players' decision making process. No player was allowed to play the game twice.[3]

3. Results

Beauty contests have often been designed as one-shot experiments, which corresponds to only looking at the results in round 1 of our experiments. Like in the classic papers on this topic (e.g. Nagel [24], Ho et al. [19]), we analyze the results from the first round and from the subsequent rounds separately.

[2]Players could only select integers between 0 and 100 in our AMT experiments. While discrete action spaces may make some new equilibria arise, the only new equilibrium in our case is a profile of ones in the 8-player beauty contest. In general, when the number of players is not large, all new equilibria are profiles of low numbers, which does not affect the initial steps of the reasoning processes described in Section 1. See Seel and Tsakas [31] for more details.

[3]See also supplementary information for more details about the experimental design.

3.1. Static: First Round

Figure 1 shows the distributions of guesses from a selected sample of previous experiments on the beauty contest.[4]

The lowest means are found among theorists, in the internet newsgroup experiment, and in the newspaper experiments, all in which subjects were science and business interested and supposedly had more time to think about their answer and therefore may have been able to think further ahead. Specifically, the newspaper experiments were done in the magazine *Spektrum der Wissenschaft* [32] (with a mean of 22.1), in the *Financial Times* [33] (mean 18.9) and in the Spanish newspaper *Expansión* [3] (mean = 25.5). However, another large scale experiment with 19,196 readers of the less science and business oriented Danish daily newspaper *Politiken*, reported a mean of 32.4 [30] (not shown here).

The presence of spikes in the vicinity of 22.2 and 33.3 in the majority of experiments shown in Figure 1 constitutes evidence that subjects can be described as performing one or two iterations of best response reasoning. thus replicating the findings of Nagel [24], and upholding the IBRd model as the prominent description of how people reason about each other and behave in the beauty contest as stated in Fact 1 and Fact 2 above. As this pattern of behavior is found both in lab and in newspaper experiments, the data corroborates the assumption of parallelism between the lab and the field (newspapers), as we have seen in Fact 3.

Our findings from AMT, shown in the bottom right graph of Figure 1, tell a different story. First of all, while the mass of all other distributions is concentrated

[4] Of course there have been made many more one-shot beauty contests, see for instance Schou [30], Rubinstein [28]. Here we only show those distributions where we could get hold of the complete data set.

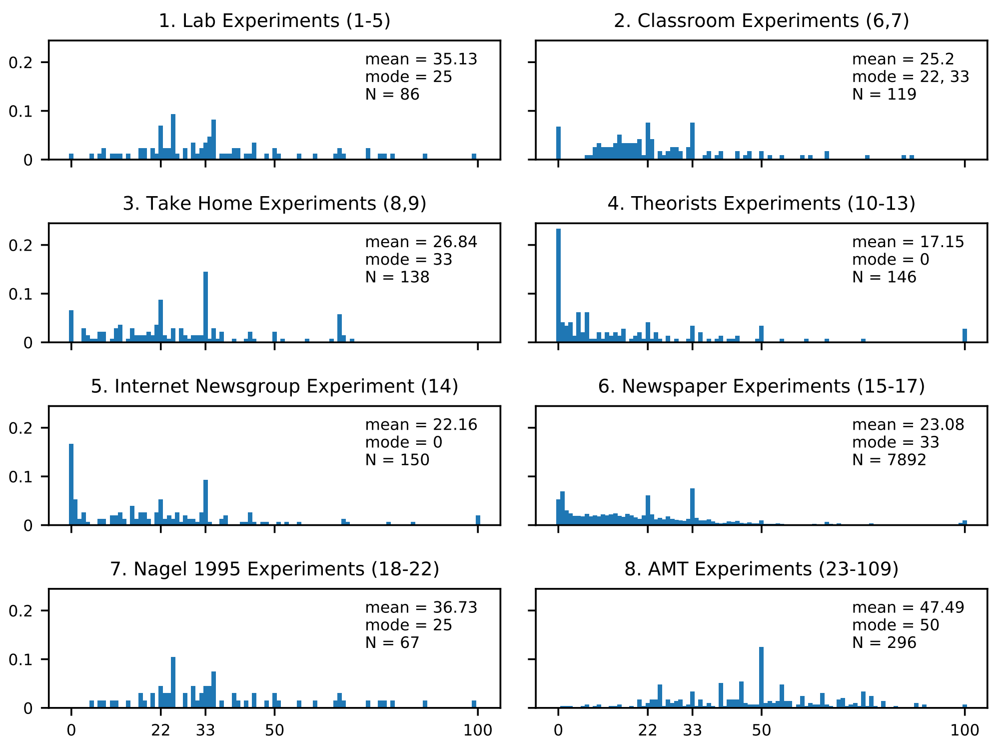

Figure 1: The first six subplots show the distributions of the guesses from various "one shot" newspaper [33, 32, 4] and lab experiments as analyzed by Bosch-Doménech et al. [3]. The bottom left subplot depicts the distribution of guesses in the first round in the experiments by Nagel [24], while the bottom right subplot shows the distribution of the results we collected from the first round on Amazon Mechanical Turk.

on the left half of the interval [0,100], the distribution of the data from AMT is close to normal ($p = 0.047$, Shapiro-Wilk test) with mode 50 and mean 47.49, and has mass concentrated around the center of the interval and spreading away symmetrically in both directions. Moreover, the three different treatments all have means above 45 (50.99 for 2-player groups, 45.42 for 4-player groups and 45.96 for 8-player groups), and the mode is 50 for each treatment too, overall indicating a propensity towards a middle number in the first round.

Second, unlike the other seven distributions in Figure 1, the one from AMT has no notable spike either around 33.33 or around 22.22. A major spike at 50 is instead present, which corresponds to the modal choice, while lower spikes appear more or less symmetrically on both sides of it. We can therefore state the following:

Finding 1. *No spikes confirming the effect of some iterations of IBRd reasoning are found.*

The IBRd model assumes that the iteration process starts from 50, as detailed previously in Section 1. Such a starting point may be interpreted as the expectation from randomly choosing according to a symmetric distribution around 50, or as the choice of a salient number à la Schelling [29]. The distribution of choices on AMT is compatible with both these hypotheses: given the marked central spike, we can exclude that the symmetric distribution is uniform, hence supporting some sort of salience in the number 50.

A second conclusion can then be drawn from our experiments:

Finding 2. *The behavior observed in AMT experiments is compatible with players choosing at random from a symmetric distribution with mean 50, possibly* *viewed as a salient number. Relative to the IBRd model, this can be interpreted as a population of 0-level players, choosing numbers at random or by simple salience, without any higher-order reasoning.*

3.2. Dynamic: Subsequent Rounds

Clear evidence for higher-order reasoning is not found in subsequent rounds either. Figure 2 shows the means in each of the eight rounds played on AMT by groups of size 2, 4, and 8 respectively. For comparison we show the results of the experiments by Nagel [24], by Kamm and Dahinden [21] as reported in [15], by Weber [34], and by Bühren and Frank [6], all shown in red colors.

It is common to all the experiments in Figure 2 that the means tend to decrease with subsequent rounds, which may be interpreted as a sign of learning. The speed of decrease, however, differs between the experiments in the lab and those on AMT. Nagel [24] finds a decrease of around 30 points in four rounds. It takes instead eight rounds on AMT for the means of 4- and 8-player groups to decrease by about the same, while the means of 2-player groups decrease only by around 20 points over eight rounds.

The rates of decrease of the means between round 1 and round 4 may be computed, as in Nagel [24], by the following formula:

$$\text{Rate of decrease} = \frac{(\text{mean}(1) - \text{mean}(4))}{\text{mean}(4)}$$

where $\text{mean}(r)$ is the mean in round r. The rate of decrease in the various experiments is listed in table 1:

As it can be seen from table 1, the rate of decrease of the mean in our AMT experiment are much lower than in all the other experiments done on students, which leads us to make the following finding:

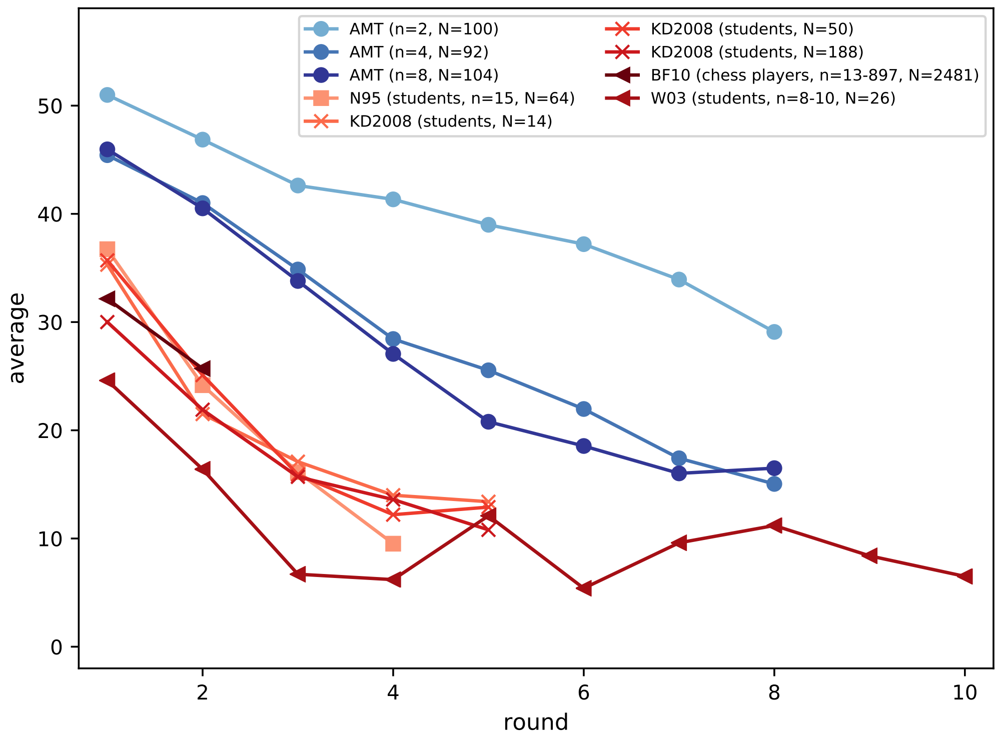

Figure 2: Means for iterated beauty contest experiments with various number of rounds played. Our AMT-experiments with group sizes 2, 4 and 8 are shown in blue colors. Results from lab experiments with students by Nagel [24], Kamm and Dahinden [21], Weber [34], and with chess players Bühren and Frank [6] are shown in red colors. Means decrease over time, although the AMT-results are markedly shifted upwards. In addition, the rate of decrease is significantly lower. The rates of decrease for the first four rounds in the AMT experiments are 0.19, 0.37, and 0.41 for group sizes 2, 4 and 8, respectively, while the rate of decrease in Nagel [24] is 0.74.

Experiment	n	N	RoD
Amazon Mechanical Turk	2	100	0.19
	4	192	0.37
	8	104	0.41
Nagel (1995)	15-18	64	0.74
Kamm & Dahinden (2008)	14	14	0.60
	50	50	0.66
	188	188	0.55
Weber (2003)	8-10	26	0.75

Table 1: Rates of decrease in iterated p-beauty contest experiments with $p = 2/3$. n = group size; N = number of subjects; RoD = rate of decrease from round 1 to round 4.

Finding 3. *The means of all treatments in the AMT experiments are significantly higher than the means of the experiments in Nagel [24], Kamm and Dahinden [21] and Weber [34]. Moreover, the rates of decrease of the means in all treatments from AMT experiments are substantially lower than the rate of decrease in the repeated beauty contest experiments by Nagel [24], Kamm and Dahinden [21] and Weber [34].*

In addition, the means in 2-player groups are significantly higher than in 4-player and 8-player groups (Kolmogorov-Smirnov tests, $p < 0.01$ in 14 out of 16 comparisons), indicating that when playing against only one player, people behave differently. As already noticed in Ho et al. [19], this is puzzling in that the smaller the group, the larger the effect of individual guesses on the mean. Two-person beauty contests are isomorphic to the game "whoever chooses the smaller number wins": while one is not guaranteed to win when choosing zero in the 4- or 8-player beauty contest, guessing zero is weakly dominant and ensures at least a tie in the 2-player game.

In our 50 experiments with groups of two players, there was no participant who chose zero in the first round. After 8 rounds, zero was chosen 3 times in total (out of 800 guesses). This is significantly lower than what was found previously by Grosskopf and Nagel [17], where about 10% of undergraduates in economics guessed zero in the one-shot version of the 2-player game.

Finally, higher rates of decrease are sometimes associated with larger groups (e.g. Ho et al. [19], p. 958), but the similarity in the means between groups of 4 and 8 players and the comparison to the results by Kamm and Dahinden [21] and Weber [34] both have comparable group sizes constitute counterexamples to that association. AMT experiments also contradict the claim that larger groups choose higher numbers at the start (see Ho et al. [19], p. 958). What holds true, instead, is that the 2-person beauty contest constitutes a puzzling case in which the players not only lack the strategic sophistication to understand the great power in their hands, but even display a tendency towards higher guesses than in groups with more than two players. A possible explanation, also suggested by Grosskopf and Nagel [17], may be based on a cognitive misconception of the game: players might aim to be as close as possible to the $2/3$ of the mean rather than to be clos*er* than the opponent to the $2/3$ of the mean. We can thus state the following:

Finding 4. *On average, participants in the 4-player and 8-player treatments guess significantly lower than in the 2-player treatment. Moreover, the rates of decrease of the means in the 4-player and 8-player treatments are significantly higher than the rate of decrease in the 2-player treatment.*

It is noticeable that simple directional learning also seems to be falsified by AMT experiments. Figure 3 pictures the distribution of the number of times a

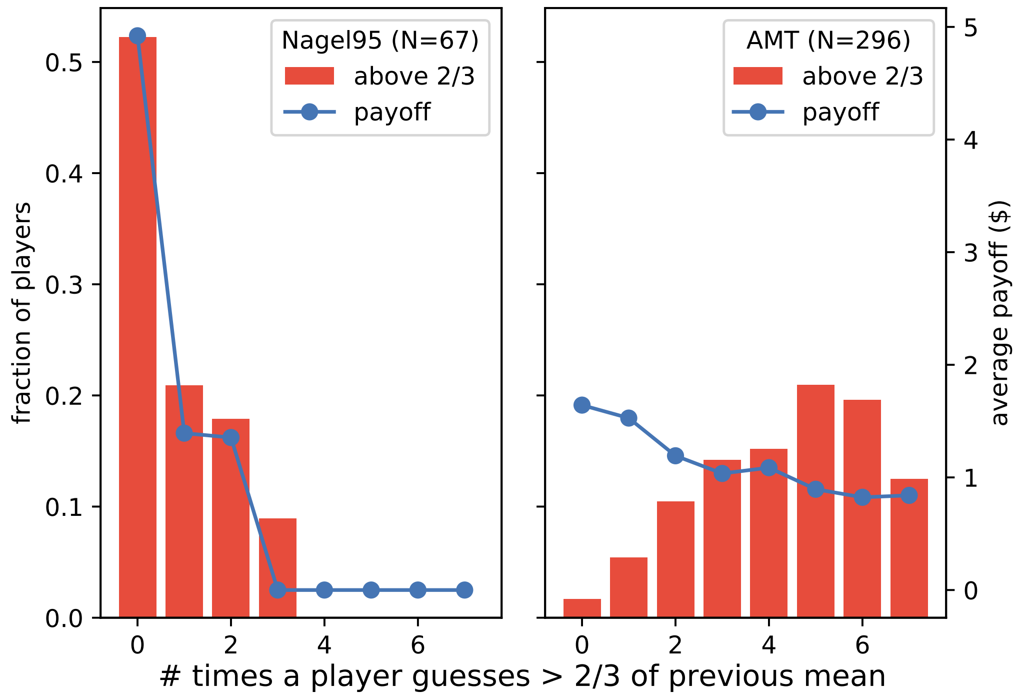

Figure 3: Bar chart of the number of times a player chooses a number greater than $2/3$ of the mean of the previous round. In the lab experiments by Nagel [24] (left) 52% of the players never go above $2/3$ of the previous mean, and only about 25% do that more than once. In the AMT experiments (right) less than 2% of players never go above $2/3$ of the previous mean, while 53% of players go above $2/3$ of the previous mean more than four times.

player chooses a number greater than the target of the previous round, i.e., greater than $2/3$ of the previous mean. Experiments on AMT, on the right, show that less than 2% of players never guess higher than the target of the previous round, while the vast majority (more than 80%) does that at least three times, and about 50% does it five times or more.

The distribution on the left, corresponding to the lab experiments by Nagel [24], depicts players of a different kind: more than 50% of players never go higher than the target of the previous round, while only about 25% do that more than once. Importantly, both in the lab experiments by Nagel [24] and in the experiments on AMT, at the end of each round players were told both the mean and the two-thirds of the mean of that round, as well as all chosen numbers. While the players in Nagel [24] seem to learn that the target decreases and adapt to this, players on AMT cannot be viewed as adapting to a decreasing target: most of the times they pick numbers higher than $2/3$ of the mean of the previous round, even while observing a decreasing sequence of means and targets.

From the assumption that, in subsequent repetitions, a player of level zero chooses at random according to a symmetric distribution around the previous mean (or the previous target), it follows that a player of level one would never guess higher than the previous target, and higher levels of reasoning imply even lower guesses. Hence, the combination of some iterations of IBRd with an adaptation process taking the mean (or two-thirds of the mean) of the previous round as reference point for the next round is incompatible with our observations from AMT. We can therefore state the following:

Finding 5. *The results from the AMT experiments are incompatible with the combination of higher-order reasoning as modeled by IBRd and learning processes taking the mean (or two-thirds of the mean) of the previous round as the reference point for the next round.*

4. Parallelism between the Field and the Lab

In light of the results above, we have to reassess the assumption of parallelism between the lab and the field. Participants in lab and classroom experiments are most often university students, sometimes even graduate or PhD students in economics, and hence cannot be considered representative of the population at large. As mentioned in Section 1, this causes issues about the sociodemographic representativeness of such samples: how general and generalizable are the results from the lab? So-called field experiments such as newspaper experiments, on the other hand, may potentially reach broader and more differentiate subject pools, but at the price of losing control on the specific sociodemographic characteristics of the sample.

One of the important contributions by Bosch-Doménech et al. [3] concerns the parallelism between the lab and the field. Accepting the experiments with newspaper readers as field experiments, the comparison between the results from newspaper and lab/classroom experiments allows the authors to evaluate the assumption of parallelism and the general validity of the conclusions drawn from lab behavior. Given the similarity between the data collected from newspaper experiments and those from various lab and classroom experiments, [3] conclude that the same pattern observed in the three newspaper experiments is replicated in the lab, and the parallelism assumption between the lab and the field is supported, as we have seen in Fact 3.

The sizable differences reported above with respect to the behavior in online experiments on Amazon Mechanical Turk would lead us to the opposite:

Finding 6. *In our AMT experiments, the parallelism between the lab and the field fails.*

5. Conclusion: A Dilemma

The main conclusions drawn by [3] on the assumption of parallelism and the common behavioral patterns observed both in lab and in field (newspaper) experiments are thus not supported by our results from AMT. Similarly to the newspaper experiments, AMT experiments reach broader and more differentiate pools than lab experiments [7, 14, 20, 27], but also have less control on the sociodemographic characteristics of the sample. As opposed to lab experiments, AMT experiments are thus to be considered field experiments.

Putting these two observations together leaves us with a dilemma. Either AMT is not a reliable platform for small and medium sized beauty contests, or the assumption of parallelism between the lab and the field (AMT) does not hold true.

In the first case, our results would contradict the literature about the validity of experiments performed on AMT (e.g. [7, 14, 20, 27]). In the second, they would go against the validation of parallelism between the lab and newspaper experiments as investigated by [3].

Arguments for the first case may include the belief that the quality of the AMT subject pool is poor in terms of monetary incentives, attention and/or cognitive ability and effort. However, the average payoff in our experiments was approximately $15 per hour, which is considered generous according to AMT guidelines and certainly above the estimated average of $6 per hour when excluding unsubmitted and rejected work [18]. In addition, the belief that data quality depends on the (relative) size of the bonus compared to the participation fee is contradicted by [1], who showed that results of standard economic games with very low bonuses on AMT are comparable to those of corresponding lab experiments with higher bonuses, thus alleviating concerns about the validity of economic game experiments conducted on AMT.

With regard to possible concerns about insufficient cognitive ability and/or effort among AMT subjects, we can only suggest that in order for economic games to be representative of the real world, they should not require subjects to be experts or be trained in any particular way. If the keynesian beauty contest were meant to test the cognitive acumen of only economists and mathematically talented people, it is clear that AMT is not the best place to do such experiments. If, however, the purpose of the p-beauty contest is to say something general about people's use of higher-order reasoning in online settings, AMT may be a good place to start.

However, the apparent lack of strategic thinking among the majority of AMT subjects is still a puzzle which needs further investigation. As discussed in Chou et al. [13] one reason may be may be that the beauty contest is an unfamiliar type of game in which subjects often lack understanding of the relationships between possible choices, outcomes and payoffs. Online platforms like Amazon Mechanical Turk, where subjects have no prior knowledge, limited time and little patience, may amplify such contributing factors. When instructions and procedures are presented with mathematical expressions like "average" and "2/3 of", subjetcs may believe that they are supposed to solve mathematical problems rather than to think about what others think. Our two-person beauty contest experiment may be a glaring example of such misconceptions. If the instructions were presented in a more familiar context and with a clear statement such as "whoever chooses the lowest number wins", strategic thinking would probably have been more prevalent [13, 5].

To conclude, the differences between our results and the results from newspaper/lab experiments are most likely due to the disparities between their subject pools. Consquently we conjecture that the similarity between newspaper and lab results may be due to the similarity between their subject pools. Although it is true that the design of the newspaper experiments entails a loss of control on the sample, it does not necessarily follow that the newspaper samples are very different and more diverse than the samples used in lab experiments. Having chosen markedly economic-oriented newspapers might have brought the experimenters not very far into the field. Further lab, field and AMT experiments that control for some of the factors discussed above should be able to answer the dilemma presented here.

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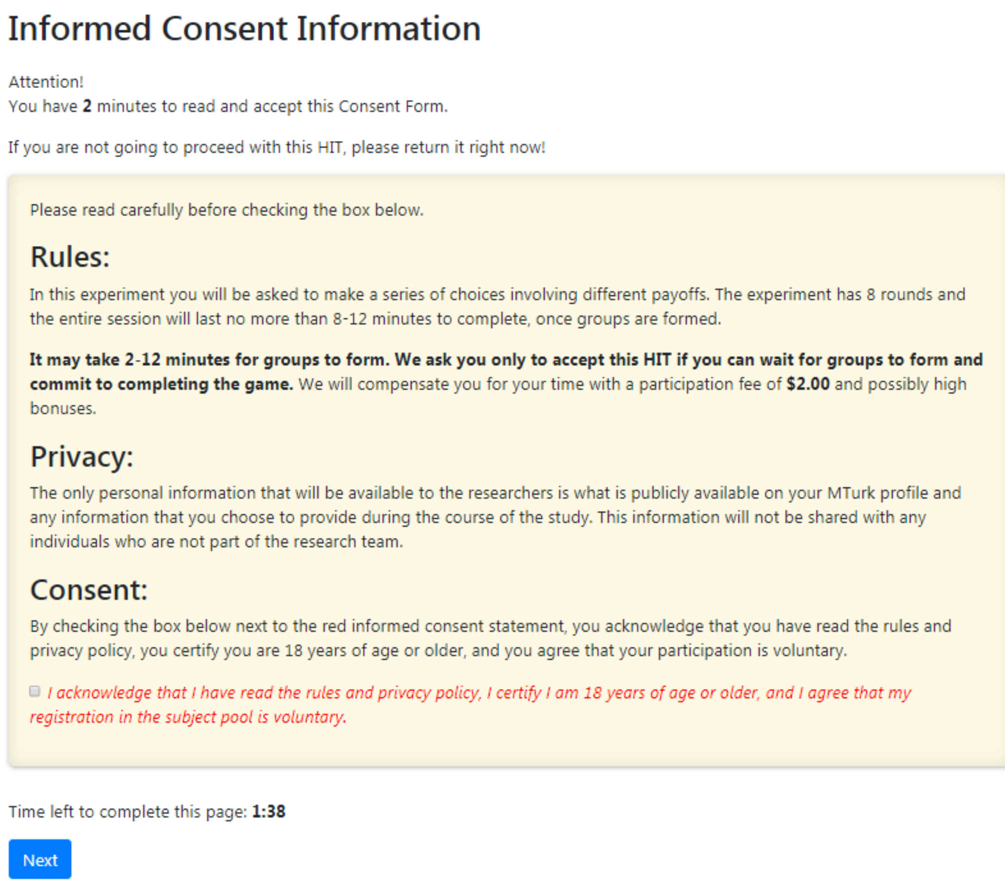
Appendix A. Materials and Method

Amazon Mechanical Turk (AMT) is an online labor market and crowdsourcing platform, which is increasingly being used for social and economic experiments in order to investigate the real time interactions of small to medium sized groups. AMT has repeatedly been shown to meet or exceed the standards set by data collection methods using other means [2, 8]. The platform has a large participant pool (called turkers), various demographic and quality selection options for researchers, and provides an integrated participant compensation system.

Appendix B. Experimental Design

After turkers accept our 'HIT' ('human intelligence task'), they have to provide informed consent, see Figure B.4. Then they wait until there are enough turkers who have accepted the HIT to form random groups (grouped by arrival) of size 2, 4 or 8, respectively, depending on the treatment condition. When group has been formed, instructions are displayed for 90 seconds, see Figure B.5. After pressing NEXT, turkers see a page where they have to enter into a form field an integer number between 0 and 100. When all turkers in a group have done so, a result page is displayed, see Figure B.6, where they can see their own guess, the guesses of the other players, the average and the 2/3 of the average as well as information about whether they have won a bonus in the current found and what their total payoff is for the time being. After this, the previous steps are repeated for a total of 8 rounds. Every time turkers enter a new number, they can see a list of the 2/3 of the average of the previous rounds as shown in Figure B.7. Turkers have 90 seconds to think about a number. After eight rounds, turkers are required



Informed Consent Information

Attention!
You have **2** minutes to read and accept this Consent Form.

If you are not going to proceed with this HIT, please return it right now!

Please read carefully before checking the box below.

Rules:

In this experiment you will be asked to make a series of choices involving different payoffs. The experiment has 8 rounds and the entire session will last no more than 8-12 minutes to complete, once groups are formed.

It may take 2-12 minutes for groups to form. We ask you only to accept this HIT if you can wait for groups to form and commit to completing the game. We will compensate you for your time with a participation fee of **$2.00** and possibly high bonuses.

Privacy:

The only personal information that will be available to the researchers is what is publicly available on your MTurk profile and any information that you choose to provide during the course of the study. This information will not be shared with any individuals who are not part of the research team.

Consent:

By checking the box below next to the red informed consent statement, you acknowledge that you have read the rules and privacy policy, you certify you are 18 years of age or older, and you agree that your participation is voluntary.

☐ *I acknowledge that I have read the rules and privacy policy, I certify I am 18 years of age or older, and I agree that my registration in the subject pool is voluntary.*

Time left to complete this page: **1:38**

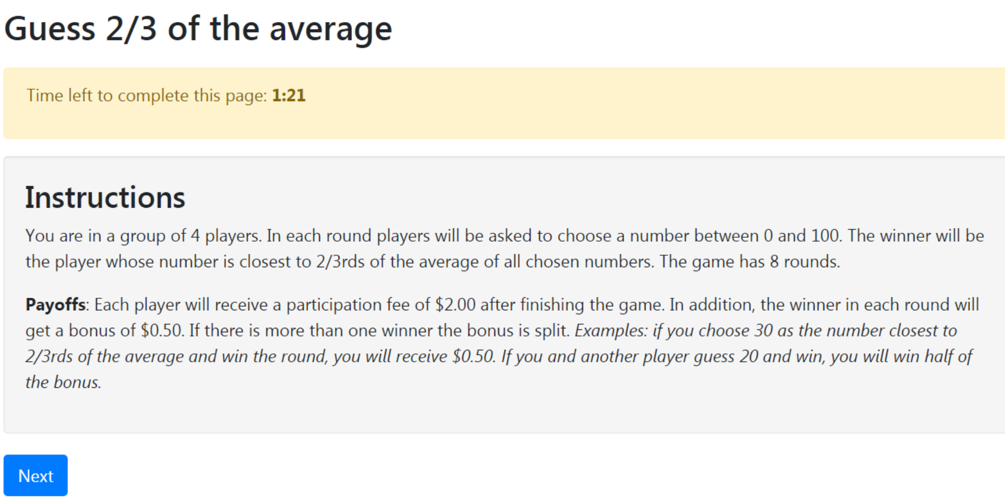
Next

Figure B.4: Screen dump of the consent page shown to all participants.

to give feedback by answering the question: 'What strategy did you use while playing this game?', after which they are thanked for their participation.

Appendix C. AMT Setting

When working with AMT it is important to consider the right settings in order to get the best data quality possible [11]. Fair wage, attrition rates, removal of duplicate workers and informative feedback are some of the most important issues to address. Average wage for turkers in our experiments was approximately $15



Guess 2/3 of the average

Time left to complete this page: **1:21**

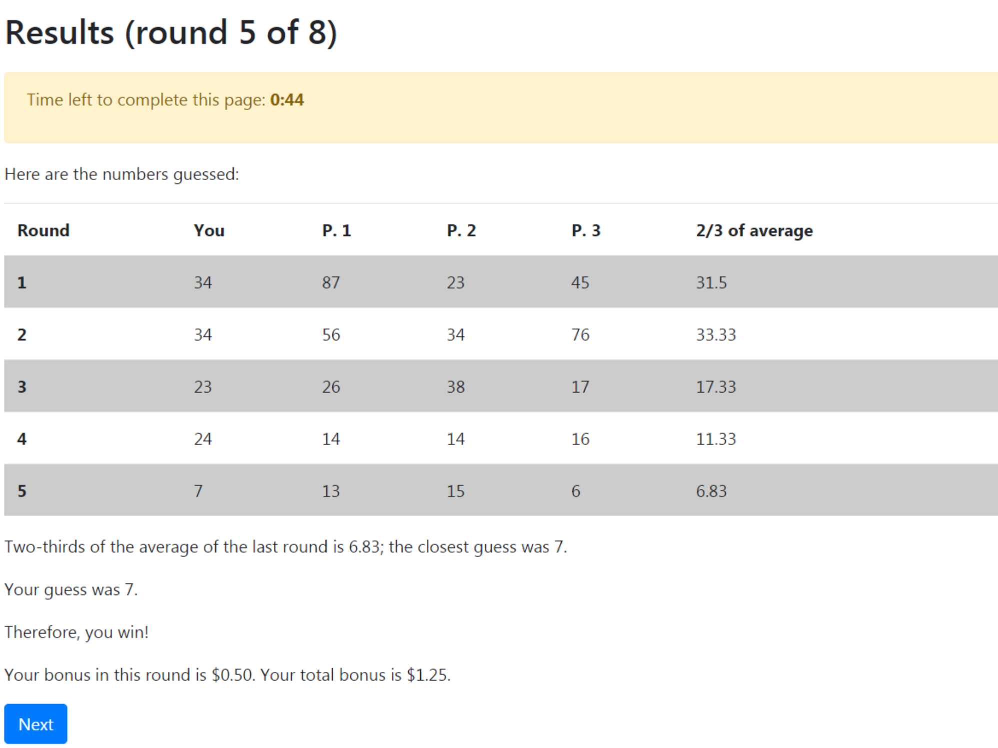
Instructions

You are in a group of 4 players. In each round players will be asked to choose a number between 0 and 100. The winner will be the player whose number is closest to 2/3rds of the average of all chosen numbers. The game has 8 rounds.

Payoffs: Each player will receive a participation fee of $2.00 after finishing the game. In addition, the winner in each round will get a bonus of $0.50. If there is more than one winner the bonus is split. *Examples: if you choose 30 as the number closest to 2/3rds of the average and win the round, you will receive $0.50. If you and another player guess 20 and win, you will win half of the bonus.*

Next

Figure B.5: Screen dump of an instruction page for a game with four players.



Results (round 5 of 8)

Time left to complete this page: **0:44**

Here are the numbers guessed:

Round	You	P. 1	P. 2	P. 3	2/3 of average
1	34	87	23	45	31.5
2	34	56	34	76	33.33
3	23	26	38	17	17.33
4	24	14	14	16	11.33
5	7	13	15	6	6.83

Two-thirds of the average of the last round is 6.83; the closest guess was 7.

Your guess was 7.

Therefore, you win!

Your bonus in this round is $0.50. Your total bonus is $1.25.

Next

Figure B.6: Screen dump of a result page from a game with four players.

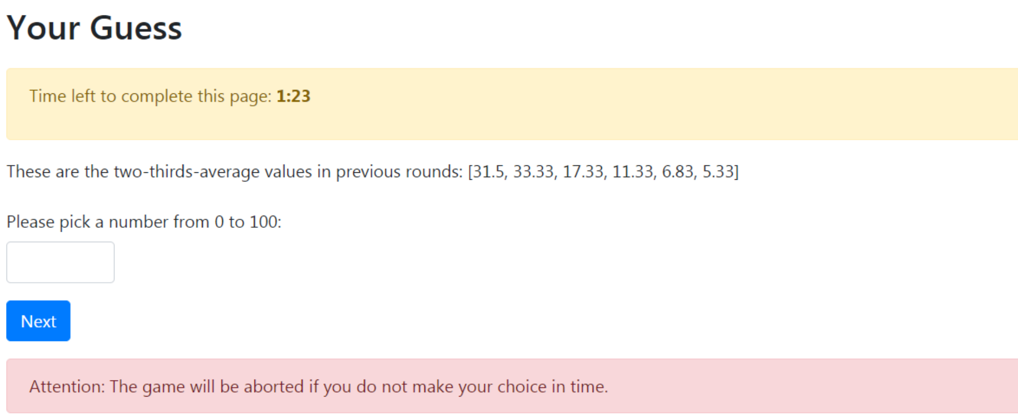


Figure B.7: Screen dump of a choice page from a game with four players.

per hour, which is considered generous according to AMT guidelines and certainly above the estimated average of $6 per hour when excluding un-submitted and rejected work [18]. Quitting a study before completing it is prevalent on AMT, and varies systemically across experimental conditions. Our overall attrition rate was 24%, which is considered normal [35]. The main reason, we believe, was either a player not being able to enter a number within the allotted time, or – more likely – due to a player not bothering to wait for the others to make their guess and therefore quitting prematurely. This was very detrimental for the rest of the group and for the experiment as such, because it meant that the rest of the group would continue the game with one player less, making the whole process much slower and skewing the results. If somebody had quit, we still let the other players finish their game and paid them for their efforts, but we decided to remove those groups from the data analysis. Out of a total of 114 initial groups, 27 groups were thus removed from the final data set, giving an overall attrition rate of 24%. All turkers automatically received a unique qualification when accepting a HIT, ensuring that they could not play the game twice. In addition, we set the qualification that workers should have completed at least 50 HITs and have an accepted HIT rate of 90% or above. This ensured that we would get experienced and qualified workers. During our experiments, participants had easy access to our email for questions and possible bug reports.

Appendix D. Code and Software

All experiments are coded in the experimental software oTree 1.4.39 [12] which is based on Python and Django. The code for the data analysis done is available on Github at https://github.com/gavstrik/game-of-regret.

Appendix E. Data Collection and Distribution

We obtained a total of 2368 guesses from 296 unique participants who played the classic iterated beauty contest game. Players were partitioned into 50 groups of size 2, 23 groups of size 4, and 13 groups of size 8.

Figure E.8 shows the guesses for all eight rounds, partitioned into their respective groups. As can be seen from the histograms, guesses move slowly towards lower numbers in subsequent rounds, with the 2-players groups (in blue) lacking slightly behind the other groups.

Appendix F. Guess Dynamics

As noted in figure 4 in the main text, players often choose numbers greater than 2/3 of the mean of the previous round. Less than 2% of all players on AMT never go above 2/3 of the previous mean, while 53% go above this target more than four times.

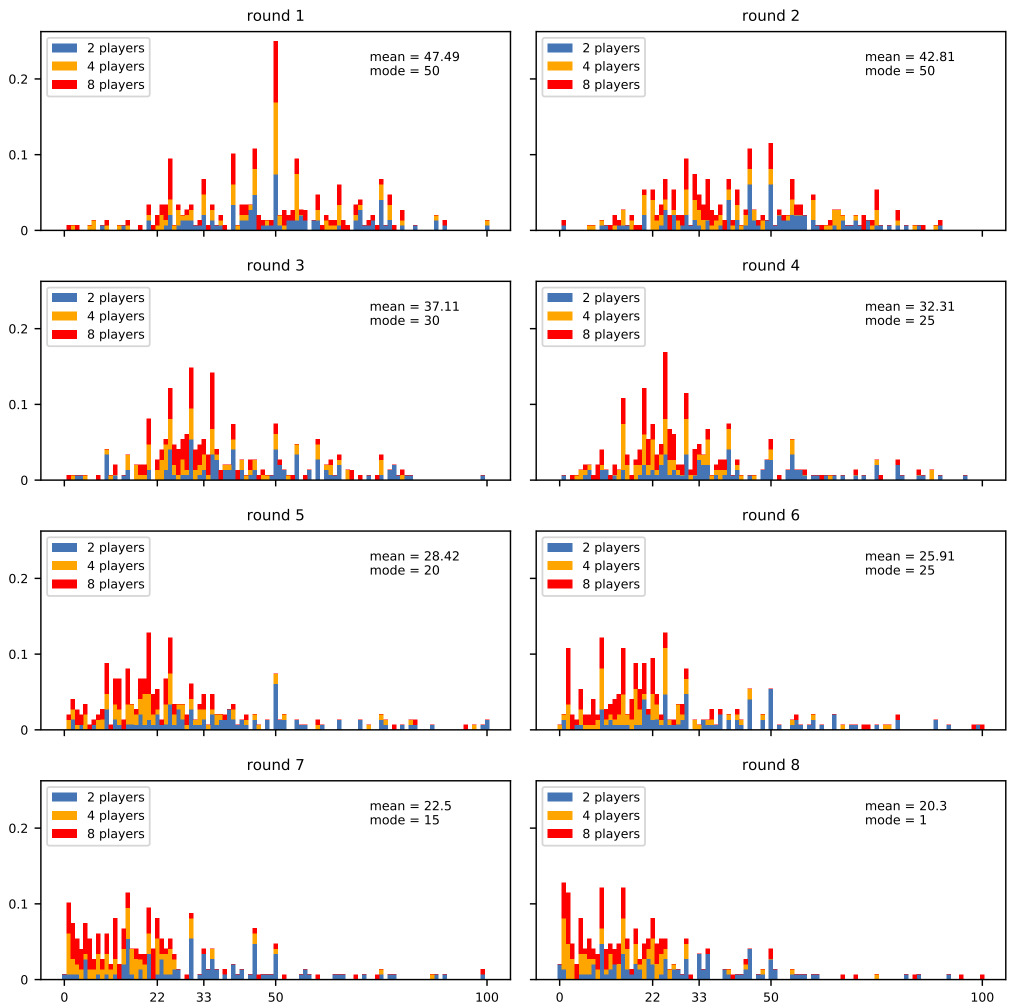


Figure E.8: Histograms of guess distributions partitioned into groups and rounds.

Figure F.9 shows the dynamics of guesses round by round in such a way that the previous round n is always shown on the x-axis and the next round $n+1$ is always shown on the y-axis. The diagonal black line corresponds to staying at the same guess in subsequent rounds. Lines connecting the dots in Figure F.9 then indicate the sequence of guesses by the same player, whose comments are shown in the legend. The total bonus earned is shown in parenthesis.

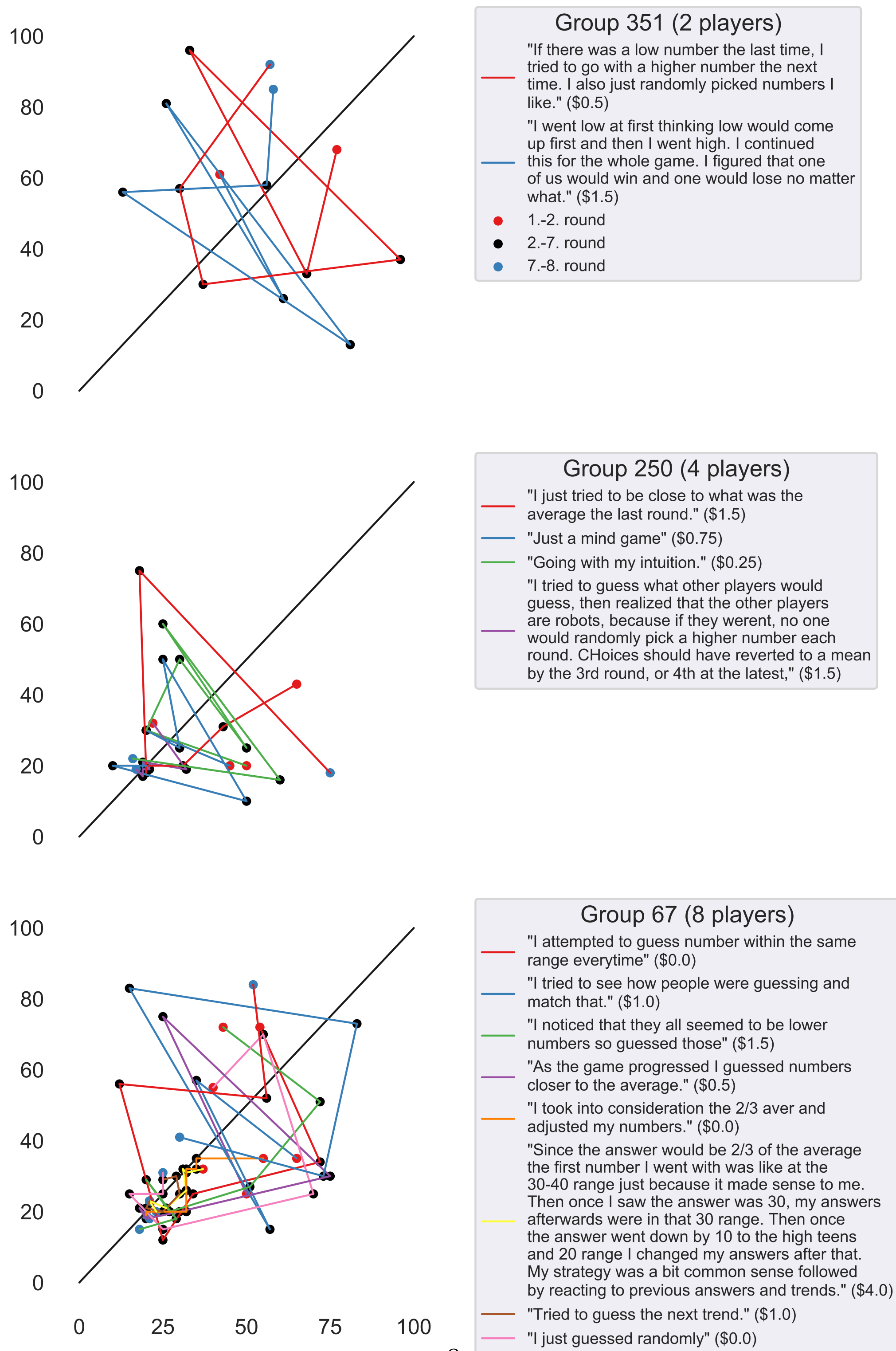


Figure F.9: Dynamics of guesses round by round.