Beauty Contest Games in the 6th Grade

By

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I. Introduction

To understand beauty contest experiments and what they can tell us, it is important to have some understanding of the principle of iterated dominance in game theory. Levels of iterated dominance are defined by the degree or depth to which a person reasons, based on the expectation of the level of reasoning of others. I have included the passage below from "The Prince's Bride" to illustrate the mental process of iterated dominance and levels of reasoning. In it I have labeled consecutive degrees of iterative dominance. In this scene Wesley plays a "game of wit" with the Italian. The game is simple. One goblet contains poison, the other does not. The Italian must choose which goblet he takes.

> *. . . All I have to do is divine from what I know of you whether you're the type of person who would put the poison into his own goblet or his enemies. Now a clever man would put the poison into his own goblet because he would know that only a great fool would reach for what he was giver. I am not a great fool so I can clearly not choose the wine in front of you* (first degree). *But you must have known I was not a great fool, you would have counted on it so I can clearly not choose the wine in front of me* (second degree). . . . *Because iocane comes from Australia, as everyone knows, and Australia is entirely peopled with criminals who are used to having people not trust them as you are not trusted by me so I can clearly not choose the wine in front of you* (third degree). *And you must've suspected I would have known the powder's origin so I can clearly not choose the win in front of me* (fourth degree). . . .

While this game incorporates the idea of iterative dominance, it does not reveal the level of reasoning of the Italian. This is because in this game different levels of reasoning can lead to the same choices. In this paper I will use a game where a player's level of reasoning can be directly read from their choice. The basic structure of the beauty contest game is useful for looking at how and whether a single player's reasoning process incorporates the behavior of others in conscious reasoning.

This paper will examine how many iterations of dominance people apply and whether their level of reasoning changes with experience. The experiments I report on are done on children and adults to allow me to investigate how levels of reasoning change with age. There will also be a discussion of how learning plays a role and how a learning effect may change the distributions of different levels of iterated reasoning in multiple rounds.

Beauty contests get their name from an analogy given by John M. Keynes for stock market investment (as Nagel 1995 pointed out). Keynes (1936 pp.155-56) said

> *...professional investment may be likened to those newspaper competitions in which the competitors have to pick out the six prettiest faces from a hundred photographs, the prize being awarded to the competitor whose choice most nearly corresponds to the average preferences of the competitors as a whole . . . It is not a case of choosing those which, to the best of one's judgment, are really the prettiest, nor even those which average opinion genuinely thinks the prettiest. We have reached the third degree where we devote our intelligences to anticipating what average opinion expects average opinion to be. And there are some, I believe, who practice the fourth, fifth, and higher degrees.*

Another example for the stock market would be as follows. Picture a large group of investors with imperfect information who are faced with selling a rising stock. Think of the time they choose to sell their stock as picking a number. When many investors sell, the stock crashes. Now think of the time of the crash as being around the average (selling time) chosen. Investors want to sell before the stock crashes, but at the same time ride the gains for as long as possible. This creates a dilemma. An investor knows that he should sell before the crash, but if he is wise to other investors with the same mindset he should try to sell at a point before average opinion dictates. But what if on average people try to sell before what average opinion dictates and this investor's reasoning is not unlike the average investor? The investor has now reached the third level of iterative reasoning, in which he bases his investment decision on what average opinion expects average opinion to be. If this investor were to dig deep into the iterative process he would either decide to sell immediately which is where such iterations lead if they are extended to infinity, or he would stop and think about where a realistic stopping point may be. This is one example (of many) given by Ho (Ho-Camerer-Weiglet 1998, p.948) which demonstrates why the level of reasoning people use matters.

In our experiment we examine this same type of reasoning in an experimental setting. Participants are asked simultaneously to choose any number between 0 and 100. The winner is the person who chooses p*(median of all the chose numbers). In our case there are two parameters, p=1/2 and p=2/3. The basic form of this beauty contest experiment has been studied with many different variations in the past and has numerous applications to economics as a way to look at both steps of iterated dominance and how people learn.

Modern game theory argues that equilibria are reached by a learning or evolutionary process rather than by reasoning (Ho-Carson-Weiglet pp. 948). The beauty contest experiment is a way to study learning empirically. The beauty contest game has a Nash Equilibrium where everyone chooses 0. In theory, this equilibrium should be reached the first time the game is played: Each player should expect that each player will use an infinite number of levels of reasoning, and make the best reply to the corresponding choice of zero.

While the concept of Nash Equilibrium incorporates simultaneous best responses, we can best see this by thinking iteratively instead. Using the p=2/3 game as an example; if we were to play the game infinitely many times with the same group of players, the mean and the winning number (2/3*Mean) would be a moving target that approaches zero (provided people are exhibiting rational behavior). To see this we need only to think through a few steps. Suppose we choose arbitrarily a mean of 50 in the first round with the round winner being 33. In the next round there should be a tendency of those people with zero order of reasoning to move closer to 33. In any case, the mean and the winning number in the following round and in subsequent rounds are decreasing at a decreasing rate with a limit approaching zero. Models of learning basically assume that people approach the Nash Equilibrium iteratively.

Why Kids?

Experiments done on kids are designed to answer the same questions on levels of iterated dominance and learning that previous experiments have attempted to answer about adults. The "p-beauty contest experiment" has been widely researched and studied with several different experimental variations. We wanted to get a better idea of the reasoning process and the levels of iterated dominance of children. We also wanted to get an idea of how children learn in comparison to the other groups that have been studied.

Experimental data from children helps us make important comparisons between age groups. Suppose children have a very poor understanding or exhibit very low levels of iterated dominance. Then we can infer that that iterative dominance is a learned behavior. We might therefore expect unsophisticated adults to behave differently than sophisticated ones, in situations such as those involving stock market investments. On the other hand, if even young children exhibit an understanding of iterative dominance, as seen by their actual behavior, we might argue that this idea is one that even unsophisticated adults can be expected to employ. Using this type of reasoning we can use the results of a comparison between "un-experienced" children and "experienced" college students to interpret differences in decision making among skilled and unskilled market players.

III. Protocol, Experimental Design and Methodology

I have borrowed the basic design and method of analysis for The Guessing Game from Nagel. The idea was to give a basic comparison between her experimental results with college students (previous experiments have focused on college level and older) and children. The main focus of the comparison will be looking at learning: on a broader scale by looking at whether levels of iterative dominance change with experience. And also on a smaller scale, whether a "learning effect" may change the distributions among levels of iterative reasoning over multiple rounds. There are two obvious differences college students and children in the sixth grade: age, and education level. Furthermore, I make the assumption that students in the public school system represent a wider segment of the population as a whole in terms of basic intelligence and socioeconomic background.

The elements in my experiments which differed from Nagel's were the subject pool, the information given to subjects (the principle difference in the rules of these experiments is that I used the median rather than the mean), and in the case of the 6th graders, communication among the subjects (see Nagel 1315 for comparison). The experiments lasted approximately 45 minutes for all four rounds. Subjects were paid a small amount for participating and the winners were paid after each round (For the experimental protocol, refer to the notes at the end of this paper). The median rather than the mean were used in these experiments. There has been no significant difference in the results of past experiments between those that use means and those that use medians. Furthermore, we decided that the median would be easier to explain to children than the mean, because the latter requires division.

The children proved that they knew the median very well when I asked them. In fact they had just finished studying it. I conducted one session using p=1/2 and one session using p=2/3 with subject pools of 15 and 19 respectively. I also conducted an experiment using p=2/3 with a group of 11 volunteers from an Economics 201 class at the University of Oregon. Despite these small samples, my results are interesting because they constitute the first test of this behavior in children. In addition, they demonstrate that it is possible to use young subjects in relatively complicated experiments.

Nagel makes a distinction between the first period and remaining based on the information available to participants in those periods. In the first period a player has no information on which to base his expectations of others whereas in the following periods he gains information on people's actual behavior and can adjust his/her choice accordingly. In the results section of paper I also separate observations in the first period from observations in following periods basing my results on the same model.

Next I will explain how levels of reasoning can be derived from choices, using the p=1/2 game as an example. To determine representative values for iterative steps of reasoning 50 is chosen as a reference point in the first period, based the assumption that if people are simply choosing randomly the median will be 50. Therefore, in the first period, a player is strategic at degree 0 if he chooses a number close to 50. A person with first degree iterative reasoning will make a best reply to random behavior. The bet reply to random behavior would be to choose 25 since 50*1/2=25. On the other hand, if he believes that many people are using first degree reasoning, he will be inclined to pick a number in the second order (50*(1/2)^2=12.5). Let R be a reference point equal to 50 in the first period and the mean of period t-1 in all other periods, p be the parameter (in this case p=1/2), and n be the degree to which a player applies ordered reasoning. Then the method for calculating the representative values for iterative steps of reasoning has a general form R*p^n. In theory, this iterative process could be carried out to an indefinite number of levels In the following periods the mean of the previous period is used as a reference point. A higher value of n, according to Nagel, indicates more strategic behavior.

Note that there is a difference between higher levels of reasoning and optimal play. Most obviously, infinite level reasoning leads to a choice of zero, which, in practice never wins. Optimal play would require estimating the proportions, of people picking different levels of reasoning. In beauty contest games, more strategic play does not necessarily equate to optimal or even intelligent play. The most strategic player is usually not the winner. Someone who picks a number far below the winning number every time doesn't have a very good strategy. (Comments support this by showing very un-strategic behavior for many of these very low picks.)

The median of the previous round would be a logical reference point in subsequent rounds if the subject assumes that the behavior of the other participants does not change from one period to the next. Hence, the iterative steps in subsequent rounds use the same method as in the first period using the median of the previous period as a reference point. On the other hand, it seems possible that people would not only update their reference point, but might also demonstrate learning. Ho characterizes two types of learners: adaptive and sophisticated. "Adaptive learners, who simply learn from past observations, choose different numbers than sophisticated learners who realize others are adapting . . ." Adaptive learners don't really demonstrate any level of learning at all. Their choices are based strictly on the winning results of previous rounds. Sophisticated learners think one or more levels ahead. They anticipate other participants adapting and adjust their picks to the level of adaptation they think will be the norm. Put differently, adaptive learners apply 1 iteration of dominance while sophisticated learners apply iterations of levels 2, 3 or higher. Given the setup of this experiment it might be reasonable to expect adaptive learners to "adapt" and become more sophisticated over time once. One signal of this type of behavior would be a decrease in choices around the first degree of iterated dominance.

While using this model it is important to keep in mind the drastic oversimplification that it involves. Participants in these experiments employ many different strategies based on widely varying levels of sophistication. The model we use doesn't come close to covering the breadth of these strategies, but it makes looking at the data much easier to look at. Looking at the data outside of these constraints would be a daunting task indeed.

To get a better idea of whether "steps of reasoning" is a good way to analyze the data, and whether higher iteration steps will be observed in later rounds (a sign of learning), Nagel breaks down the data into neighborhood and interim intervals. She defines values for interim values as the geometric means of the N's so that the interval is centered around the actual steps. This enables her to define intervals for numbers grouped around the iterative and interim providing an idea as to whether people were thinking in "steps of reasoning". In my analysis I use the same method for analyzing "steps of reasoning." It would be logical to assume that participants will pick numbers at higher iteration steps in later rounds.

III Experimental Results

I start this section with the first round results. The important issues are whether children's behavior in these games follows patterns similar to those in Nagel's experiments I ten go on to discuss rounds 2-4 focusing on how children modify their behavior in later rounds.

First Period Results:

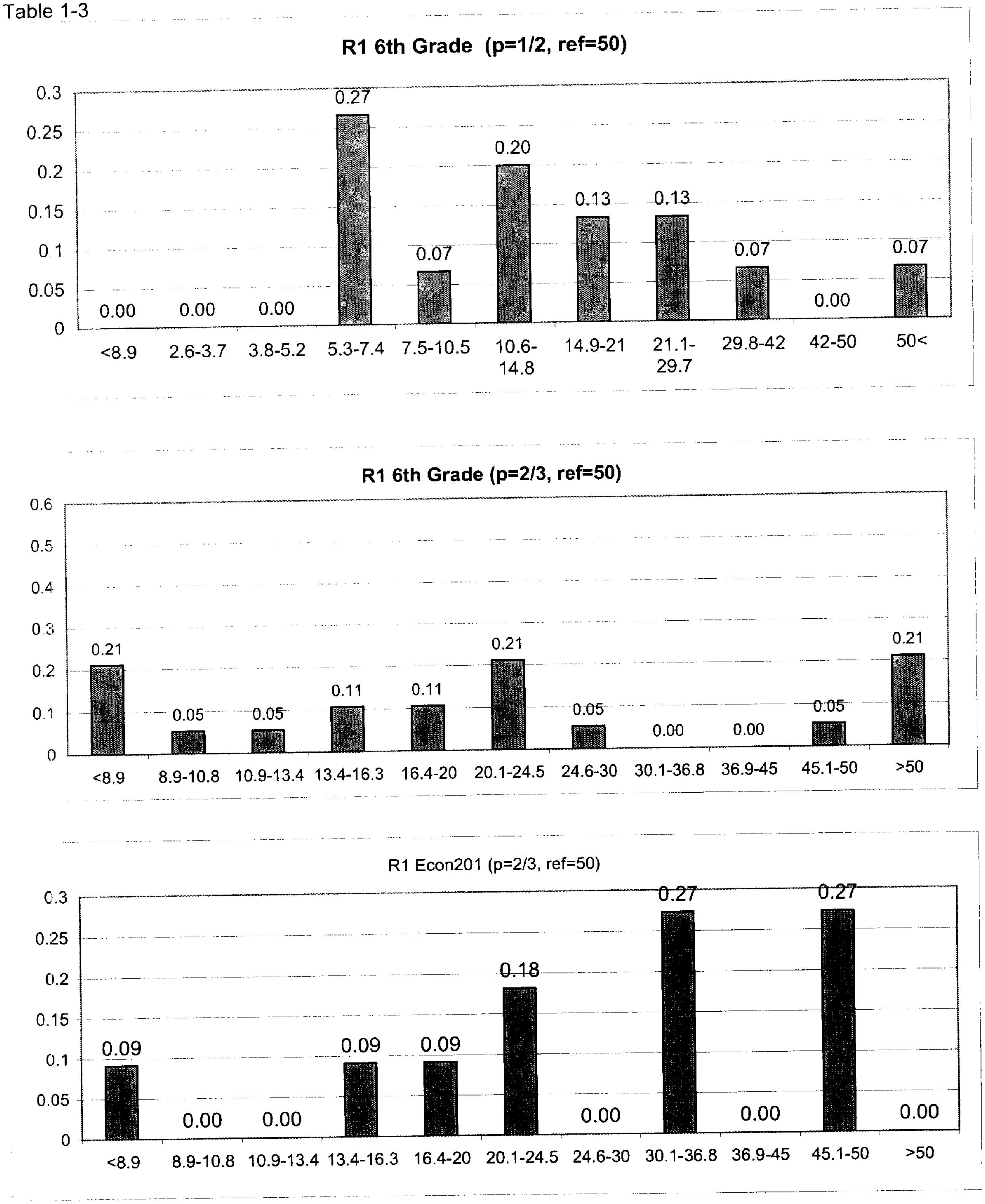
The data is charted in three different ways (histograms of interval frequencies, scatter plots of individual choices from one round to the next, and charts of directional changes in adjustment factors.) and indicates the principle methods for looking at and comparing the data. Before continuing, let me to explain how the histograms of interval frequencies are constructed and their meaning. This will help the reader understand why these methods of looking at the data were chosen and what they tell us.

Histograms of interval frequencies and their corresponding tables are perhaps the most important method of looking at the data in these experiments. The theory behind them is fairly straight-forward. We would like to look at whether the data exhibit the structure suggested by the model of iterative reasoning. In other words, do people tend to pick numbers within iterative steps of reasoning (50p^n). Of course, it would be an oversimplification to look for picks within the exact iterative steps. However, we can look at whether the data are concentrated around those numbers. For easier observation I use Nagel's method of looking at neighborhood and interim intervals of 50p^n for which n is 0,1,2, . . Interim intervals are the intervals between two intervals of 50p^(n+1) and 50p^n. I use the geometric means to determine the boundaries of adjacent intervals. This approach captures the idea that iterative steps are calculated by powers of n. The interim intervals are on a logarithmic scale approximately as large as the neighborhood intervals.

Results from the p=1/2 and the p=2/3 experiments on children:

In the experiments with p=1/2, kids are more likely to choose numbers within iterative steps of dominance from 0-3 then elsewhere on the number scale in the first round. Nagel's findings also show data for round 1 in these types of experiments to have spikes around steps 0-3. This fact suggests that the levels of iterative dominance is a good model for looking at children's behavior in the p=1/2 contests and gives us a good base for further comparison with experiments performed by Nagel. Perhaps most importantly, they demonstrate that children's play in this game is very far from random. In fact, it follows patterns that are quite similar to those for adults. Based on the histogram of the interval frequencies for round 1 (figure 1 on the following page) in the p=1/2 experiment, there is a strong indication of choices tending to be in the neighborhood intervals.

Figure 1: Histograms of Interim and Neighborhood Intervals
Table 1-3



In fact 66% (10) of the students' choices in round 1 were within the neighborhood intervals for steps one, two, and three. The modal choice with 27% of the observed picks, belongs to iteration step 3. The optimal choice in this round was 6.5, which also belongs to iteration step 3. In Nagel's findings the modal intervals are around the 1^{st} and 2^{nd} steps of iterative dominance. The comparison between students at the college level can be made easily by looking at (figure 2) on the following page. While the college students show similar results to Nagel with the majority of picks being neighborhood intervals from 0-2 (a higher proportion are at level 0), most of the picks for the children are concentrated in intervals 2 and 3 or higher. What does the modal choices being lower in experiments with children tell us?

Figure 2: Shows Interval Choices by Experiment for Period 1 (Values are Percentages)

Round 1 Degree Reasoning by Experiment

	Experiment		
Degree Reason	p=1/2 (Kid)	p=2/3 (Kid)	p=2/3 (EC)
0	0	6	27
1	13	0	27
2	20	21	18
3	27	11	9
4	0	6	0
Median	13	18	33
Winner	8.66	12	22

Note: Numbers shown are proportions of all observations

In the experiment with p=2/3 there seems to be a much lower level of understanding among the children in the first round than in the first round of the experiment with p=1/2. In the experiment with p=2/3 the modal choice is a 3-way tie between picks greater than 50, picks in the neighborhood of iterative step 2 and picks below iterative step 4. These account for 22% each or 66% of all picks. Only 7 picks out of 18 were within the neighborhood intervals 0-3. Results from the p=2/3 experiment with college students as well as Nagel's experiments show strong tendencies for picks to be within neighborhood intervals (73% of the picks in round 1 are within the neighborhood intervals for steps 0-2).

Why does our model fail to explain the behavior of children in the experiment with p=2/3 and not in other experiments? Based on the comments (see Appendix A)that the 6th grade subjects gave in the 1st round of the p=2/3 experiment, I gathered that they had a more difficult time reasoning their answer than in the p=1/2 experiment. Also, I believe there was a general lack of ability working with the fraction of 2/3. Only 4 students in the p=2/3 session indicated any reasoning at all and none of them gave any indication that they were thinking iteratively. One student chose 56 "because it's a little higher than 2/3 of 100." Another chose 55 because "I think people will pick between 10 and 100." There were lots of choices in the genre of lucky numbers: my dog's age, my age, cool, etc.

These results are a stark contrast to those of the subjects in the p=1/2 session. They seemed quite comfortable with their reasoning. Nearly one-half of the participants in the experiments with p=1/2 made clear statements of at least 1st order reasoning and one-third expressed 2nd order reasoning or higher in their comments. One student who chose 7 commented using 3 steps of iterated dominance, “People won’t pick over 50 and so the median would be 25. A lot of people would put twelve and half of 12 is 6, but my lucky number is 7.

Data from the first round in both the p=1/2 and p=2/3 games for 6th graders indicate unusually small mean and median picks in the 1st round. The distributions of picks in the p=1/2 and p=2/3 games are skewed heavily toward the low end with median picks of 13 and 18 respectively. Contrast these results with the results of the p=2/3 college student experiment (median 33) and the results from Nagel in which she gets medians of 17 and 33 for p=1/2 and p=2/3 respectively. This is a very interesting result. It would be even more interesting if these higher levels of iterative reasoning continued in rounds 2-4. If this were true it would suggest that the sixth graders play *more* strategically than college students!

Figure 1 shows the frequencies of observations in each of the neighborhood and interim intervals for the 1st round. In both 6th grade experiments, over 50% of 1st round picks were at or below the neighborhood interval for step 2. However, based on the reasons that the subjects gave for their decisions, it is reasonable to assume that low picks are not necessarily an indication of 6th graders being geniuses. In both experiments combined 65% (22) of students guessed, picked their favorite number or didn’t put a reason. Of the 35% (12) that divulged their reasoning, only 7 (all of them in the p=1/2 experiment) mentioned a reference point. Only 2 of these 7 people chose initial reference points other than 50. One chose the age of everyone in the class (12) and another said they thought the median would be 30.

The trouble with looking at comments:

Another reason this experiment is interesting is that it goes beyond analyzing behavior based solely on choices. Comments, or what people report as their strategy is a new element used in these experiments. Analyzing behavior through is not without its flaws however. For example, in the p=2/3 experiment with college students the comments and the actual choices the students may tell contrasting stories. (The college students' *comments* in my experiment with p=2/3 don't seem to correspond to the iterative reasoning we would expect from our model, yet their *choices* seem to fall nicely within neighborhood intervals.) Comments don't take into account raw intuition which plays a large role in decisions in the real world. What a subject calls a guess may really be backed by strong rationale. Due to the extremely skewed distribution towards the low end in the 6^{th} grade p=2/3 experiment, I have a difficult time making a connection between cognitive levels of reasoning and choices. If they really had no clue then why doesn't the data show more random behavior? Despite all of the things that comments don't tell us, they are also useful for figuring out levels of iterative dominance. I was surprised to see that many children, at least in the p=1/2 session, had a very good grasp of iterated dominance at 2 iterations and were even able to walk through the iterations step by step.

Periods 2-4

Obviously participants are not playing the Nash Equilibrium in first round play. Why not? One possibility is they are iterating towards it. In this section we investigate this possibility with particular emphasis on the question of how they modify their behavior. In reality, behavior in these experiments is very complicated to analyze.

Participants employ many different strategies based what they think other students will pick. They may make choices based on any number of very complex strategies. These strategies may take into account proportions of other players that includes expectations of a combination of strategies which the player expects others will employ. Modeling behavior using iterative levels of reasoning leaves out many possible strategies of reasoning, but it is a simple way to model and makes the analysis simple. It will allow us to make important and useful inferences about behavior of children in these types of games and will allow us to compare children's and adult's learning.

One thing apparent in the first round of the experiments with children is that children make choices at higher levels of reasoning than older participants. One way we can look at whether this is simply a first round phenomenon is to calculate the rate of decrease from round one to round four. The rate of decrease of the median is calculated by taking the difference of the median values in the first and fourth rounds and dividing it by the median value of the first round. The rate of decrease measures the behavior of the group as a whole. On a scale from zero to one rate of decrease close to one means that over four periods the data converges very rapidly towards the equilibrium of zero. A lower rate of decrease implies a slower convergence over the four rounds. A rate of decrease equal to zero would mean complete convergence (everyone chooses zero).

Figure 8: Shows changes for each experimental session by round (values are percentages)

Table 1: Experiment with p=1/2 6th Grade

Degree Reason	Round 1	2	3	4
0	0	7	0	0
1	13	40	27	13
2	20	20	47	20
3	27	0	7	13
4	0	0	0	7
Median	13	7	2	0.45
Winner	8.66	4.7	1.3	0.3

Table 2: Experiment with p=2/3 6th Grade

Degree Reason	Round 1	2	3	4
0	6	11	5	5
1	0	16	53	32
2	21	11	11	11
3	11	0	0	0
4	6	0	0	0
Median	18	13.8	8.9	6.3
Winner	12	9.2	5.9	4.2

Table 3: Experiment with p=2/3 (Econ201)

Degree Reason	Round 1	2	3	4
0	27	0	27	0
1	27	9	9	0
2	18	9	9	36
3	9	18	9	18
4	0	9	0	0
Median	33	14	12	5
Winner	22	9.3	8	3.3

Note: Numbers shown are proportions of all observations

In the one-half experiments, 6th graders are on the high end when compared to Nagel's results. Their rate of decrease was .97 in four rounds. This is very similar to Nagel's three reported sessions in which the rates of decrease were .88, .98 and .97. On the other hand the rates of decrease in the p=2/3 experiments are low in comparison to both Nagel's results and the results for the Econ 201 class. In four sessions of the p=2/3 experiment, Nagel's rates of decease ranged from .7 to .91. The rates of decrease in my 2/3 experiment with children was only .65. (See figure below) The sample sizes are small, but the similarities make it hard to reject the hypothesis that children are as sophisticated in these games as older participants.

Figure 4:
Rate of decrease:
Nagel 2/3=.7 .91 .71 .76
Nagel 1/2=.88 .98 .97
6th Grade 1/2=.97
6th grade 2/3=.65
EC201 2/3=.85

The scatter plots in figure 11 on the next page give us a closer look at behavior of subjects over time. These plots show the subject's choice in round t on the x axis and their choice in round t+1 on the y axis. Dots below the 45 degree line show participants whose choices are decreasing. Dots above show choices that are increasing. In both the p=1/2 and p=2/3 experiments there is a definite convergence toward the equilibrium point of zero agreeing with earlier findings by Nagel. In the p=1/2 session, 39 of 45 (3 transition periods*15 subjects) picks are below the 45 degree line which indicates that the majority of picks decrease over time. Of the 6 picks that were above the 45 degree line, none of the comments in the t+1 round indicate iterative reasoning. The medians and the means decrease over time, moving consistently towards the equilibrium. By round 4, 9 of 15 observations were less than 1, however no individual chose 0.

Figure 9: Rounds 2-4 Frequencies

Table 1-3: Experiment w/ p=1/2 (Kids)

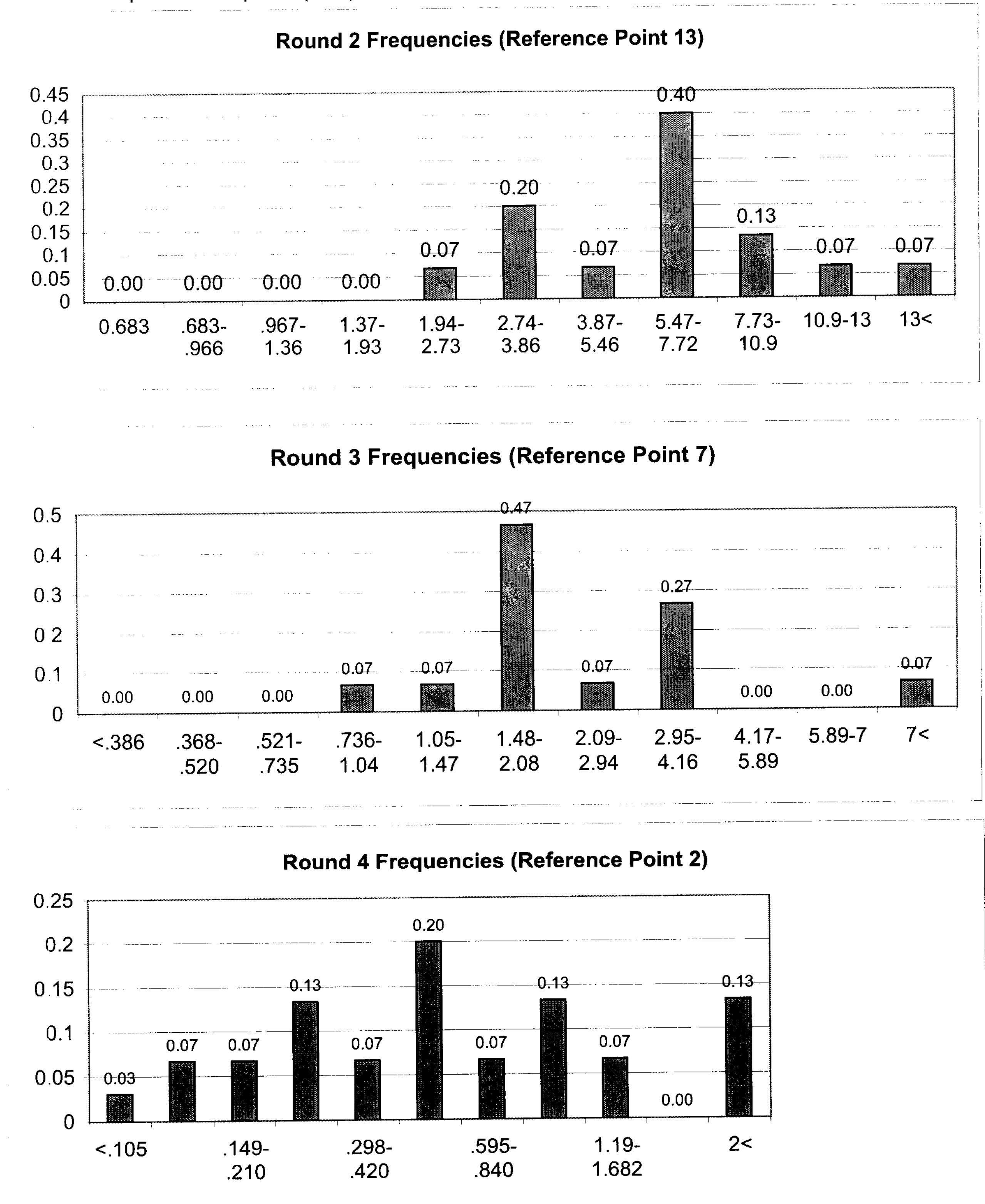
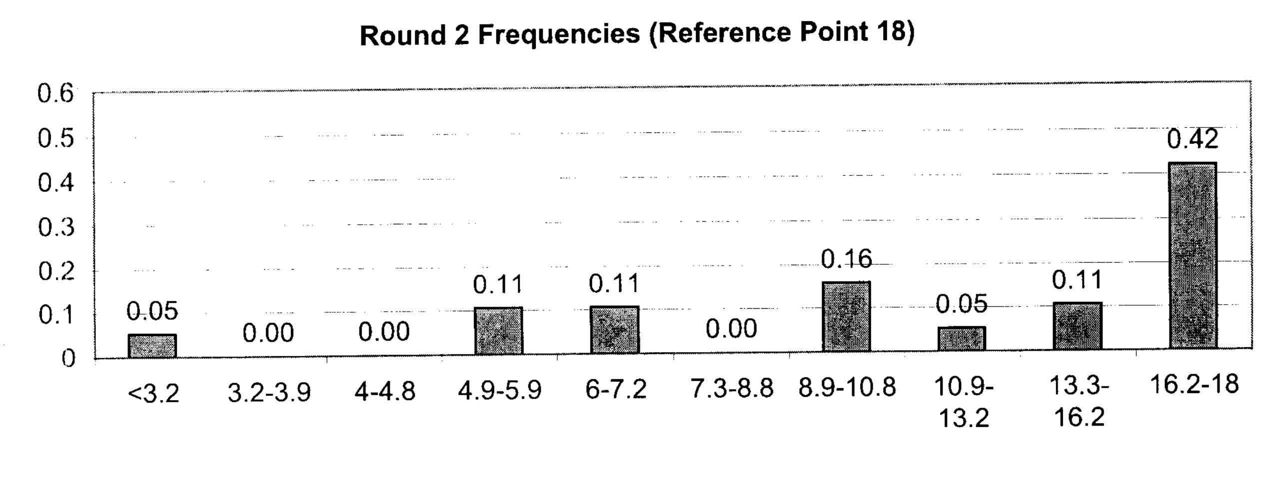
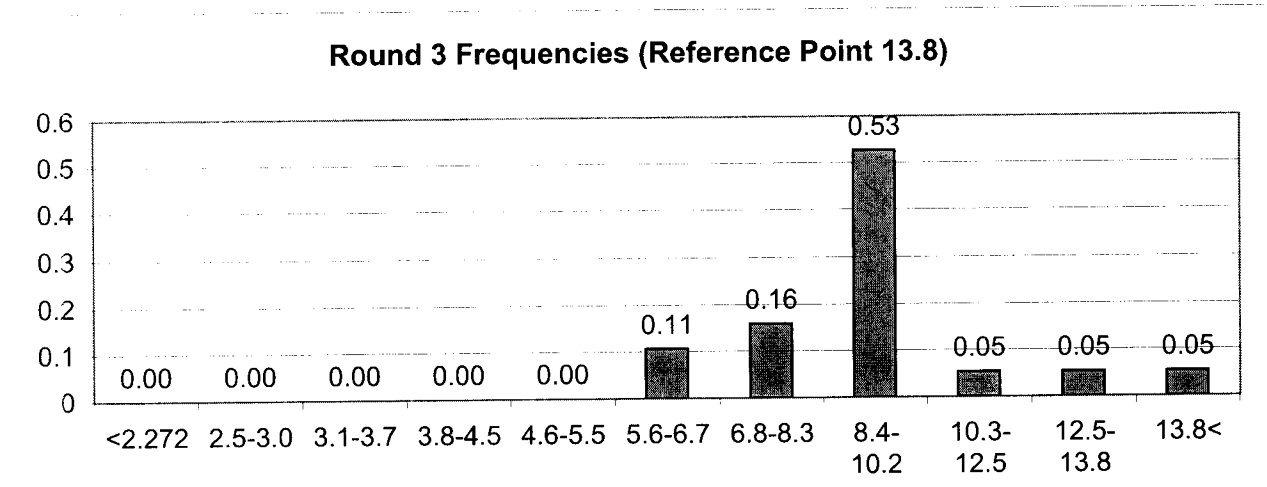


Figure 10: experiment w/p=2/3 (Kids)
Table 1-3:





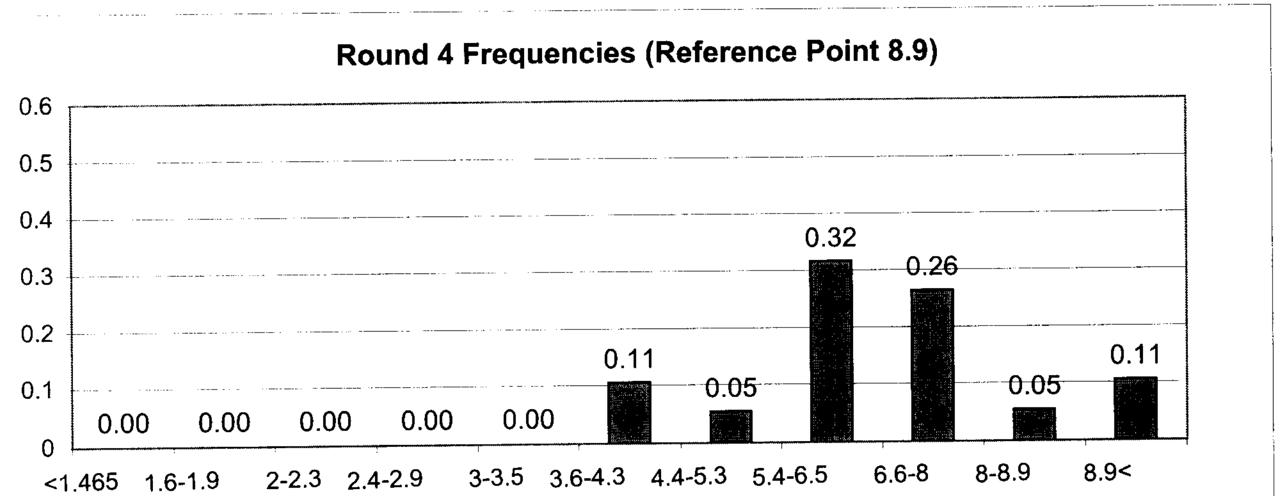
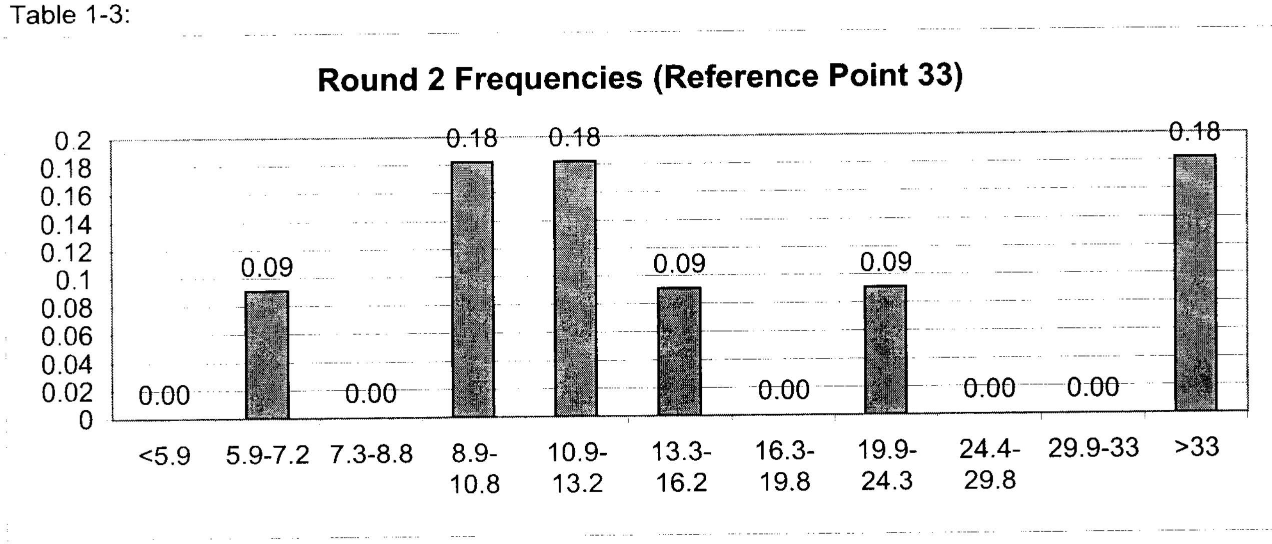
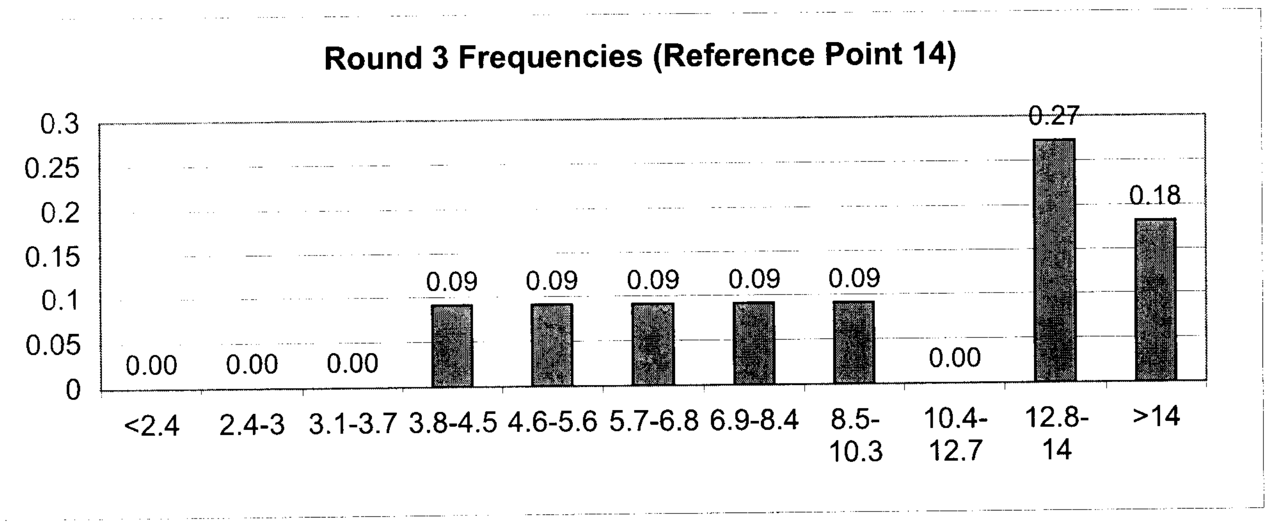
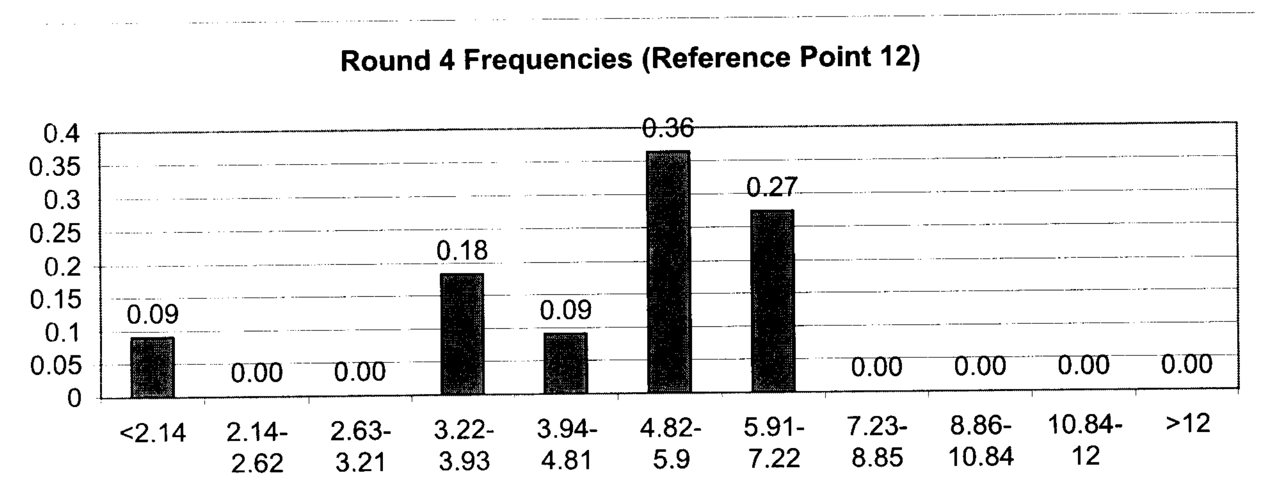


Figure 11: Experiment w/ p2/3 (Econ201)
Table 1-3:

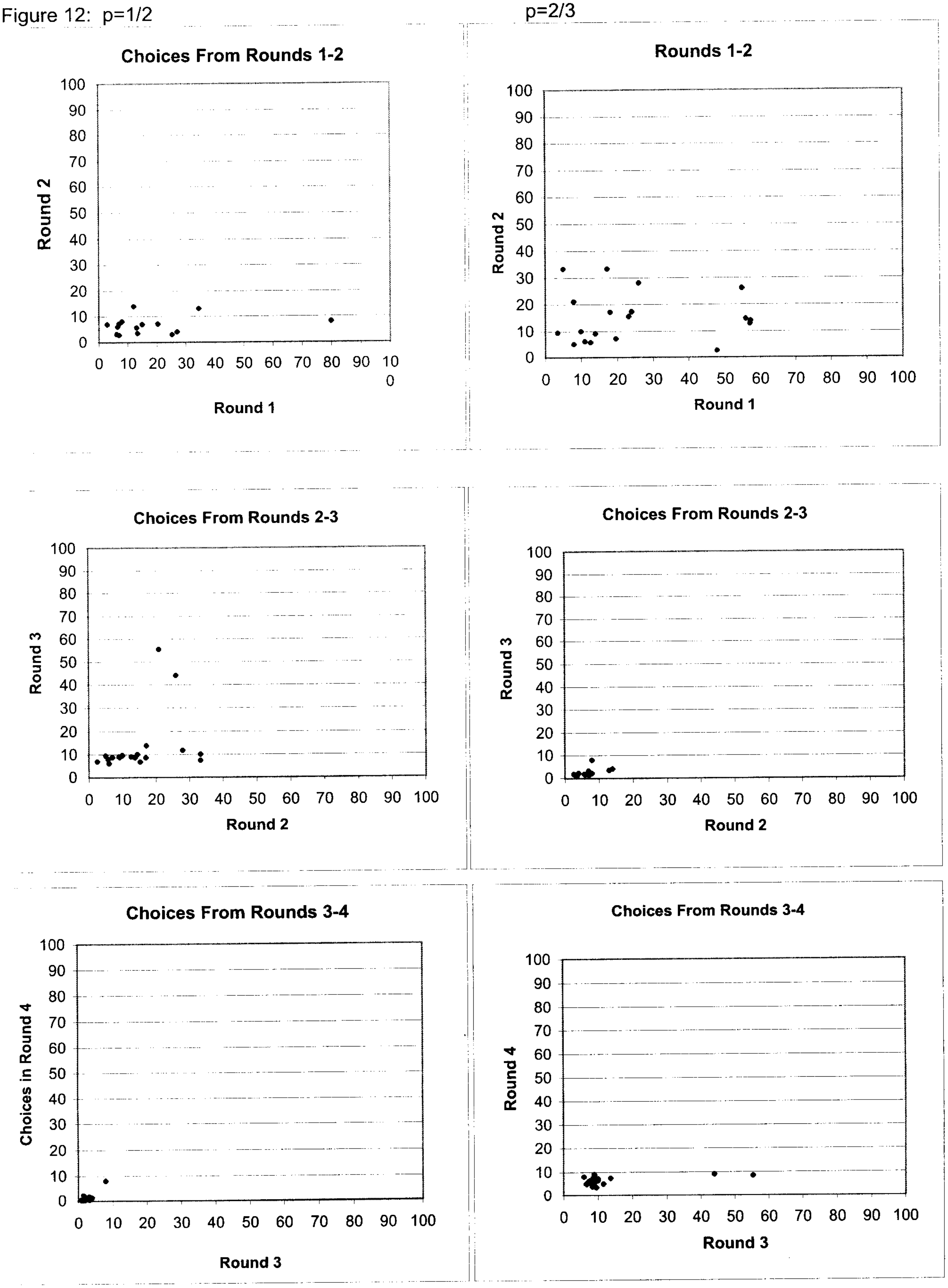






One can see that kids' choices in the p=1/2 session approach the equilibrium faster than choices in the 2/3 sessions. Based on Nagel's results and on theory we would expect this to be true. We can see this by noting that 6th graders demonstrate higher levels of learning and reasoning (figures 9 on next page), and a faster rate of decrease in p=1/2 session than in p=2/3 session.

Figure 12: p=1/2 p=2/3



In rounds 2-4, in the p=2/3 session there are more choices within the iterative intervals, however based on comments and on the erratic behavior of individuals there appears to be a lower level of reasoning than in the p=1/2 sessions. One thing that can be said is that students are acting on a less "strategic" level in the p=2/3 than in the p=1/2 experiment. In round 2 of the p=2/3 experiment, only 33% of the picks fall into neighborhood intervals for iterative steps 0-3. In rounds 3 and 4 step 1 is the is the dominant level of reasoning with 53% of the picks in round 3 and 33% of the picks in round 4 being in the within the neighborhood interval of step 1. Picks around iterative reasoning levels other than one are almost nonexistent (15% including step 0 and step 2 combined in both rounds 3 and 4). This means that by the third and fourth rounds the majority of students are still using a simple updating strategy to make their choices. In other words they tend to pick around the winning number of the previous round. This behavior is also demonstrated by the low rate of decrease in the p=2/3 round.

Conclusions:

In this paper I use the beauty contest to compare children and adults' use of levels of iterated dominance and the speed of convergence to Nash Equilibrium.

My first result is that children's behavior in p-beauty contests is very similar to that of older participants. In the first round, the proportions of children using various levels of reasoning are remarkably similar to the proportions of adults.

The results suggest that children's behavior in p-beauty contest experiments can be modeled using levels of iterative dominance. Children's play in these experiments is very far from random.

Despite all of the things that comments don't tell us, they are also useful for figuring out levels of iterative dominance. I was surprised to see that many children, at least in the p=1/2 session, had a very good grasp of iterated dominance at 2 iterations and were even able to walk through the iterations step by step.

I also found that children's learning is remarkably similar to that of adults. In both the p=1/2 and p=2/3 experiments there is a definite convergence toward the equilibrium point of zero agreeing with earlier findings by Nagel. In the p=1/2 session, 39 of 45 (3 transition periods*15 subjects) picks are below the 45 degree line which indicates that the majority of picks decrease over time.

In conclusion, children exhibited behavior and levels of reasoning and learning and reasoning surprisingly similar to adults.

Appendix A: Raw Data/Comments

Figure 1: Linda Berry's 6th grade, P=1/2, n=15

Round 1

alla	7	lucky #
Ari	80	favorite #
becky	27	b/c people choose 3's between 0-100 so 27 is around 1/2 that median of 50 or around 50. I just like 27, mostly I just Guessed.
bobby	8	I like 8
brat	12	Favorite # and it's lucky
cj	13	most people will choose below 50, some people will choose 1/2 of 50 so I'm going to choose about 1/2 of that
curly	3	because I think that ost people will think that everyone else will pick 12 because that is their age so they will pick 6 and 3 is 1/2*6
daniel	6.5	
david	34.5	
hippie	15	I think that 30 is about what the median will be.
jameson	25.25	I figured the median would be about 50 as it's right in half of 0 and 100
Joey	20.3	guess
kyle	13.4	other people might pick in the 20's because they might think other people will choose in the 40's or 50's.
trevor	6.25	
webfoot	7	People won't pick over 50 and so the edian would be 25. A lot of people would put twelve and half of 12 is 6, but 7 is my lucky #.

Median: 13, Winner: 6.5

Round 2

alla	7.052	Lucky #
Ari	8	it's smaller
becky	4	Now, everyone will want to choose a lower # like 8 or 9 so I will choose an even smaller #.
bobby	8	I like 8.
brat	14	My sister's lucky #.
cj	5.67	I think the median will be around 12 because of last time
curly	7	In astronomy my 3 is 7.
daniel	6	because
david	13	I think it's going to win

hippie win!	7	People seem to be picking #'s in the teens and 20's. Hope I
jameson this time.	3	Most people chose 12 last time so most people will choose 6
Joey	7.1	guessing
kyle	3.5	it is 1/2 of the nuber that won last time
trevor	3.125	1/2 the # I chose last time.
webfoot	2.7	they are my lucky 3's

Median: 7, Winner: 3.5

Round 3

alla	3.14	because
Ari	2	smaller
becky	2	most people will want to go higher this time
bobby	8	
brat	4	because it's lucky
cj	1.6	median is going lower so I'm going lower.
curly	3	astronomically the art #. I love art.
daniel	1.53	b/c it's cool
david	3.26	Because I like the number.
hippie	2.5	People are choosing pretty low #'s.
jameson	1.5	most people will choose 3 this time as it won last time.
Joey	1.351	don't know
kyle	0.9	1/2 of what everyone else will choose.
trevor	1.5	Because it's 1/2 of y last #.
webfoot	1.7	17 is my volleyball #.

Median: 2, Winner: .9

Round 4

Alla	1.665	just because
Ari	0.5	Just a hunch.
becky	0.25	cause it will probably get down pretty low this time.
bobby	8	I like the nuber 8.
brat	1	b/c small unlike some other #'s on the overhead
cj	0.055007	cause people are going lower
curly	0.75	don't know
daniel	0.3	cause it's a winner
david	0.45	b/c .9/2=.45
hippie 1	fits the range people are picking in	
jameson	2.25	everyone is doing y strategy so I'll do 1/2 my strategy
Joey	0.2	don't know
kyle	0.15	b/c it's 1/2*1/2 of the number that won last time.
trevor	0.225	b/c it's 1/2 of what I think others will choose.
webfoot	0.45	

Median: .45, Winner: .225

Figure 2: Ms. Barry's 6th grade math. P=2/3, n=19

Round	1	
andrea	57.4	no idea
andrew	8	I like 8.
ashli	17.3	favorite #
bethany	57.2	I like it.
brad	48	guess/lucky #
brady	14	I think everyone will guess low.
buba	55	I think people will pick between 10-100.
chandell	26	guess/lucky #
cody	56	because it's a little higher that 2/3 of 100
crissy	3.5	I like it.
dennis	19.7	one of my lucky #'s
Emily	11	I like this #
kasey	9.999	I like the # 9
krislyn	23.2	most people would choose higher #'s. I know that 25*3=75, one popular hight #, so I changed it a little.
marie	18	I like it.
mike	8	guess/lucky #
Ramstead	12.666	
sarah	5	lucky #
scott	24	this # is cool

Median: 18, Winner: 9.999

Round 2		
andrea	13.8	
andrew	21	I like 21
ashli	33.33	guess
bethany	12.66	I like to color.

brad 2.5 everyone is guessing 11

brady 9 it is low and everyone guesses low

buba 26 it's a number.
chandell 28 guess
cody 14.5 will probably be closer to the answer.

crissy 9.3 I love 9.3.
dennis 7 it's my lucky #.
Emily 6 guess
kasey 9.999 b/c I like it.
krislyn 15.333 it came to my head

marie 17 came to my head first.

mike 5 lucky #
Ramstead 5.7 it's a low #
sarah 33.333 it is 2/3 of 50

scott 17.123 it's a #

Median: 13.8, Winner: 9.3

Round 3 p=2/3

andrea 8.5 because 9.3 won last time and 8.5 sounds like it could win.
andrew 55.4 my football #

ashli 7.2 guess
bethany 8.9 it is pretty

brad 6.8 it will win
brady 9
buba 44 football #
chandell 11.59 guess
cody 10 it's between the other 2 winning #'s

crissy 8.7

dennis	8.7	
Emily	6	guess
kasey	9.59	guess
krislyn	6.6	In the second round, most people chose numbers from 7-21.
I thought		
		that 2/3 of most of the numbers wold be around 6.6
marie	8.5	it came to my head
mike	9.3	
Ramstead	7.8	7.8 is high but not too high
sarah	10	it's between the other 2 winning #'s
scott	13.72	

Median: 8.9, Winner: 6

Round 4 p=2/3

Andrea		4	
andrew		8.444	
ashli	5.9	guess	
bethany		5.1	I like it
brad	5		
brady	9		
buba	9		
chandell	5.1	it was a guess	
cody	7.3	guess	
crissy	7.7		
dennis	5.3		
Emily	8	don't know	
kasey	3.59		
krislyn	5.2	most people chose around 7-10 in the last round.	
marie	4.589	it came to my head	
mike	6.3		
Ramstead	6.555		
sarah	6.5	don't know	
scott	7.468	dunno	

Median: 6.3, Winner: 4

Appendix B

The Rules

Please wait until I read all of the rules before you write anything on your slips of paper. After I am done explaining the contest you may ask questions.

Please do not talk during the experiment and do not let anyone else see your decisions.

There will be four rounds and each round will have the same rules.

In each round you will be asked to choose a number between 0 and 100. You can use decimals if you want.

The winner of each round is the person who picks the number that is closest to 2/3 of the median of all the numbers picked for that round.

The Procedure:

Write the number you choose on the card of the corresponding round and include an explanation for your choice in the space provided. After you are done, fold the slip of paper and remain quiet while the rest of your peers finish. **Nobody else in the class will know what choice you made.** Remember to write your name and the round number at the top of your answer sheet.

At the end of each round all cards for that round will be collected, the numbers chosen will be written on the board, and the median will be determined. The winner of each round is the person who picks the number that is closest to 2/3 of the median of all the numbers picked for that round.

Again, be sure to write the reason you chose your number on your explanation sheet. YOU WILL BE GIVEN FIVE MINUTES TO MAKE YOUR DECISION SO THINK CAREFULLY AND DON'T RUSH.

For the 2^{nd}, 3^{rd}, and 4^{th} rounds you will get 2 minutes to think about your choice.

Prizes

Everyone who participates in all four rounds will get $1 cash. In addition, the winner of each round will get be paid $20 cash. The $20 will be split in case of ties. I will pay the winners at the end of each session.

ARE THERE ANY QUESTIONS BEFORE WE BEGIN?

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