Beauty is in the Eye of the Other Beholders:
Strategy Matching in Financial Markets

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ABSTRACT

How accurately do capital markets price assets? The Efficient Market Hypothesis (EMH) posits that market prices represent the best possible estimate of true value, but advocates of behavioral finance have argued that they can deviate substantially from true value.

Camerer and Fehr (2006) suggest that the resolution of this debate depends on the type of strategy used by better-informed investors, who will correct mispricings if they have an incentive to do the opposite of what other players are doing (substitution strategies), but will accentuate mispricings if they have an incentive to match other players' strategies (complementary strategies). EMH assumes that strategies in financial markets are substitutes because better-informed investors focused on objective value will buy when others undervalue an asset. Keynes (1936) suggested that strategies in financial markets are complements because better-informed investors focused on resale value will "pre-imitate" others by buying when they believe others plan to buy.

I propose that a key factor determining whether investors substitute or complement is whether they construe the nature of their task as determining an objective value or anticipating subjective opinion. In four experiments, I offer evidence that:

(1) individuals are more likely to match strategies when the object of judgment is the opinion of others than when it is an objective value
(2) the value an individual assigns to a risky asset is influenced by the opinions of others
(3) in a market environment, individuals are likelier to match strategies when relative performance is made more salient

This research suggests that individuals in a market setting are predisposed to use complementary strategies because they tend to construe the nature of their task as anticipating subjective opinion, partly because this construal rests on a valid theoretical basis and partly because it is empirically valid when enough participants act as if it were true. I propose that a consequence of this tendency is that coordination games offer a useful model for analyzing market phenomena such as momentum beliefs.

Introduction: Rationality and Irrationality in Financial Markets

How, and how well, do financial markets work?

Economists have long argued that markets are extremely effective mechanisms for aggregating information, and, indeed, numerous "prediction markets" such as the Iowa Electronic Markets have demonstrated impressive forecasting accuracy (Wolfers and Zitzewitz 2005). This empirical track record has provided support for the Efficient Market Hypothesis ("EMH"), a long-standing theory widely accepted by economists, which asserts that prices established by highly liquid markets represent the best possible estimate of the true value of financial assets.

In opposition to the evidence of prediction markets, however, is the observation that financial markets frequently appear to generate "bubbles" -- rapid changes in prices that are difficult to explain by reference to changes in underlying fundamental economic metrics. For example, the NASDAQ price index more than tripled in the last three years of the 20th century, only to fall by 75% over the next two years. Though such severe fluctuations may appear irrational, they fail to constitute proof that asset prices were wrong at the market top, since there is no way of knowing the a priori probability that prices might have continued to rise instead (e.g., Pastor and Veronesi 2007). Thus, any attempt to test whether real-world financial markets price assets accurately requires an independent theory of what asset prices ought to be. Given that no such theory exists, it is not surprising that there is little agreement among economists about whether or when bubbles occur (Hunter, Kaufman, and Pomerleano 2003).

In the absence of a clear standard for evaluating the rationality of financial market outcomes, this paper will focus instead on the underlying processes that generate those outcomes. Specifically, I will examine a key assumption underpinning EMH, that the critical process that drives market prices towards their true value is "arbitrage" by people with superior information and judgment. EMH supporters accept that many investors may act irrationally or be subject to psychological biases in their reasoning, but they assert that better-informed investors will use their information advantage to buy when the market price is too low and to sell when it is too high, in both cases driving the price closer to the correct value. Since those felicitously endowed with superior insight will make money at the expense of the less fortunate, as time passes the financial shepherds will accumulate more and more money as the financial sheep get shorn. The end result is a market dominated by the shepherds and hence a very accurate market price.

Though this assumed process is theoretically persuasive, there is surprisingly little empirical evidence to support it. Berg and Reitz (2006) summarize results from several studies of the Iowa Electronic Markets as demonstrating that though most traders do not appear to be fully rational, the high accuracy of prices is driven by a small group of "marginal traders" who do not show the same biases. But they note that "who these traders are and exactly why they drive market efficiency remains largely a mystery" (p. 163).

In addition to this lack of empirical support, the assertion that better-informed investors will correct the mistakes made by irrational ones is also questioned theoretically in a recent paper by Camerer and Fehr (2006). They argue that the extent to which rational or irrational players will dominate a social interaction depends on whether strategies in the setting where the interaction occurs are "substitutable" or "complementary." Strategies are substitutes if agents have an incentive to do the opposite of what other players are doing; they are complements if agents have an incentive to match other players' strategies. The authors provide evidence that when strategies are substitutes, even a minority of rational agents can result in aggregate rationality, while when strategies are complements, even a minority of irrational agents can result in aggregate irrationality.

EMH assumes that strategies in financial markets are substitutes; if the market consensus results in a price that is too low relative to the cash flows an asset will generate in the future, smarter investors will buy, and if it is too high, they will sell. Though this logic appears compelling, it is challenged by an alternative viewpoint first proffered by John Maynard Keynes (1936). Keynes rejected the notion that "competition between expert professionals… would correct the vagaries of the ignorant individual left to himself" because he believed that those with greater than average judgment and knowledge are "largely concerned, not with making a superior long-term forecast of the [value] of an investment… but with foreseeing changes in… what the market will value it at, under the influence of mass psychology, three months or a year hence" (pp. 154-55).

In other words, Keynes argued that sophisticated investors do not try to take advantage of the behavior of less sophisticated investors by "substituting" and doing the opposite, but by "complementing" and doing what the crowd will do *before* they do it. Rather than buy when the market price is too low and sell when it is too high, sophisticated investors buy when they think the market price is going higher and sell when they think it is going lower.

Experimental Asset Markets

EMH has also been challenged by experimental research on laboratory asset markets, a paradigm created by Smith, Suchanek, and Williams (1988). In these experiments, participants trade an asset that pays a dividend for a fixed number of periods and then expires worthless. Since the only value of the asset is its finite dividend stream, EMH makes a clear prediction that the market price should approximate the remaining expected value of the dividends. Instead, dozens of studies have demonstrated that the most common observed price pattern is a bubble: average trading prices begin below expected value but then exceed expected value for a number of periods before "crashing" near the end of the game (Porter and Smith 2003).

Despite the robustness of these results, this research has had relatively little impact on the debate among economists about bubbles, primarily because the vast differences between laboratory and real-world asset markets make it difficult to determine whether the apparent similarity between observed price patterns results from the same underlying dynamic or is mere coincidence.

In particular, EMH advocates point to one of the very few manipulations that reliably eliminates laboratory bubbles, namely multiple stationary replications. That is, if the same group of participants plays the game together a second time, the bubble pattern typically recurs, but in the third repeated game, prices track expected value. Dufwenberg, Lindqvist, and Moore (2005) present evidence that in mixed groups of inexperienced and thrice-experienced players, even a minority of the latter can reduce the likelihood of bubble formation, leading them to suggest that their findings may be more representative of real-world markets, which are presumed to be dominated by experienced investors.

But bubbles have also been observed in experiments using subject pools of small business persons, mid-level corporate executives, and even over-the-counter market dealers (Porter and Smith 2003), suggesting that the key factor causing bubbles is not the general inexperience of the players, but rather their inexperience with this specific task. What is it about this particular task that results in bubbles?

The answer appears to be that inexperienced experimental asset market participants prefer complementary to substitution strategies. Specifically, Caginalp, Porter and Smith (2001) propose that experimental bubbles are the result of players using a "momentum strategy", i.e., buying on the expectation of a further rise in price. This is a complementary strategy because a player who expects prices to rise will be a buyer, so that if the majority of players hold that belief, their demand for the asset will itself cause the price to rise, creating a self-fulfilling prophecy. In this situation, every other player has an incentive to also buy in anticipation of the price rise.

Though a common real-world investment strategy, momentum investing is of questionable rationality. In markets without a definitive endpoint, theoretical modeling has demonstrated the possibility of "rational bubbles" where momentum strategies continue to raise prices indefinitely, but the conditions needed for these models to work are sufficiently restrictive that there is doubt whether they could actually occur (Meltzer 2003). Regardless, the strategy is irrational for the average player in the finite setting of the laboratory; since the asset is worth zero at the end of the game, the final buyer of the asset on the basis of a momentum strategy is clearly acting irrationally. By backward induction, therefore, all previous buyers are also irrational because they are relying on the irrationality of a subsequent buyer.

In other words, the essential logic of EMH is correct in the experimental setting. The total payoff to all players in the game is defined solely by the exogenously determined dividends, so that trading is a zero-sum game. Since at the end of the game the shares are worthless, those who play the substitution strategy of buying whenever the price is below objective (expected) value and selling whenever it is above (a "value" strategy) will have higher average expected earnings than those using any other strategy (because they will collectively be on the positive side of any trades). Why, then, do so many players use momentum strategies in this setting?

Motivations for Matching Strategies

Keynes (1936) proposed that better-informed market participants choose to match the strategies used by less-informed players because they are concerned not with "what an investment is really worth to a man who buys it 'for keeps'" but rather with "anticipating what average opinion expects the average opinion to be" (pp. 155-56). EMH attempts to sidestep this distinction between inherent value and resale value by assuming that better-informed players will assume that future resale value (i.e., average opinion or the market price) will be the same as inherent value.

Empirically, in experimental asset markets resale value is not the same as inherent value, so if better-informed investors make this assumption, it is questionable to call them better-informed. Rather, the majority of players act as if they believe that resale prices will be determined not by expected value, even though this is public knowledge, but by other players playing complementary momentum strategies despite the incentive to do the opposite.

In order to evaluate if and when a similar process occurs in real-world financial markets, we need to understand the origin of this belief. Following Keynes, I propose that the essential feature of this process is the belief that the object of judgment is collective opinion rather than objective fact. Camerer and Fehr (2006) offer as an example of an environment which incentivizes the use of matching strategies a game with precisely this characteristic. In the Beauty Contest, players attempt to guess closest to some multiple of the average of all players' guesses. When the multiple is less than one, any player who believes that other players will act rationally will recognize that the game has a single Nash equilibrium of zero, yet this guess is empirically never correct in an inexperienced group because even a single player guessing otherwise can shift the average. In this setting, then, players have an incentive to anticipate average opinion rather than calculate the "rational" answer, which requires that they take into account the strategies used by other players.

> Hypothesis 1: People are more likely to match strategies when the object of judgment is the opinion of others than when it is an objective value

Unlike in the Beauty Contest, the object of judgment in the experimental asset market has an objective value. Here, the strategy with the highest expected earnings is to buy at any price below expected value and to sell at any price above expected value. While it is possible some players might reliably be able to do better than average by trying to forecast average opinion, the average player, by definition, cannot. Why, then, does the average player choose to match the strategy of other players?

Lei, Noussair, and Plott (2001) argue that the origin of this "decision error" lies in a failure by participants to "fully understand the nature of the task," that is, they fail to understand that the correct value of the asset, its expected value, is determined exogenously by the experimenter and that this value, rather than the opinion of others, ought to determine the price which they should pay for the asset.

But even within standard financial theory, the price ascribed to an asset depends in part on the subjective preferences of market participants, specifically their risk preferences. Only a risk-neutral player will want to maximize average earnings and thus be willing to pay exactly expected value for the asset; a risk-averse player will want to reduce the variation in potential outcomes and thus will value the asset at less than expected value, while a risk-seeking player will want to increase the variation in potential outcomes and thus will value it at more than expected value.

Finance theory treats risk preferences in the same way that economic theory treats consumption preferences: that is, it assumes that people know what their preferences are and that they are uninfluenced by the preferences of others. But there is considerable evidence that consumption preferences are influenced by the preferences of others (Wooten and Reed 1998) and reason to believe that risk attitudes are highly likely to be as well, since research has shown that risk attitudes as inferred from choice are influenced by subjective perceptions of riskiness (Weber and Milliman 1997; Weber and Hsee 1998) and emotional reactions to stimuli (Loewenstein, Weber, Hsee, and Welch 2001; Weber, Siebenmorgen, and Weber 2005), both factors shown to be subject to social influence (Sherif 1935, Asch 1952, Barsade 2002).

As a result, the price that a given individual will ascribe to a risky asset may be determined, in part, by the value that others place on it, who will themselves be influenced by the opinion of others, and so on. In other words, value will emerge from a process endogenous to the pricing system itself, in which case subjects are *not* mistaken in believing that the nature of the task is, at least in part, forecasting average opinion.

> Hypothesis 2: The value an individual assigns to a risky asset is influenced by the opinions of others

While Hypothesis 2 could explain price fluctuations in some narrow band around expected value for the laboratory asset, it cannot in itself explain bubbles of the magnitude often observed, with prices sometimes exceeding even the maximum potential value of the asset. These extremes could be explained, however, by the fact that a widespread belief that the nature of the task is forecasting average opinion can be self-fulfilling.

In the context of the laboratory this is only true temporarily, since at the end of the game the asset is worth nothing, making the opinion of others irrelevant, and making those who believe that it is not irrelevant poorer. EMH supporters point to the fact that repeated experience in the game eliminates bubbles to argue that a similar process occurs in the real world: since individuals who focus on inherent value will collectively gain money from those who do not, over time market prices will be determined by the former group. The critical question then becomes why experimental market participants who recognize that the value of the asset is actually objectively determined fail to dominate the pricing process in inexperienced groups.

One obvious possibility is that there simply aren't enough such players, which some research suggests may also be the case in real-world markets (De Long, Shleifer, Summers, and Waldmann 1990; Barber, Odean and Zhu 2006). But experimental bubbles occur even with groups of subjects with substantial market experience or when subjects are allowed to "short" shares, effectively offering greater leverage to sophisticated players, suggesting that the explanation lies in the choice by sophisticated players to also complement. Specifically, asset market researchers have argued that the observation of "irrational behavior on the part of other traders… promotes speculation" (Lei, Noussair, and Plott 2001, p. 858) because "even traders who had not planned to implement a momentum strategy are forced to recognize it as an important factor in determining the temporal evolution of prices" (Caginalp, Porter and Smith 2001, p. 81).

Neither group of researchers offer an explanation, however, of why this recognition would cause rational players to complement rather than substitute. Since the average player using a value strategy will earn more than the average player using any other kind of strategy, a momentum strategy is only rational for an individual player if that player is able to garner sufficient positive returns from other momentum players to overcome the profits foregone to those playing a value strategy. But this requires that they be able to predict when the momentum-driven increase in price will reverse, which Caginalp, Porter, and Smith (2001) note is generally not predictable even by experimenters using sophisticated mathematical models based on a more complete set of information than the players typically have.

Alternatively, use of a momentum strategy could still be rational even if it results in lower average earnings if players have objectives other than maximizing average earnings. The notion that individuals might have multiple goals is uncontroversial in general, though there is considerable debate about how decision makers resolve conflicting goals (Krantz and Kunreuther 2006). In the social setting of a market, one plausible alternative goal is to "win", i.e., to have the highest earnings in the market. Camerer and Fehr (2006) allude to such a concern with relative outcomes in asserting that "institutional constraints such as performance pressure mean that… well-informed investors can be forced to follow a poorly informed crowd, rather than betting against it" (p. 51). While experimental markets lack "institutional constraints," research suggests that people care about relative outcomes even in the absence of incentives directly tied to relative performance (Frank 1985, Solnick and Hemenway 1998, Neumark and Postlewaite 1998, Frank and Sunstein 2001, Diener and Biswas-Diner 2002, Schoenberg 2004, Firebaugh and Tach 2005, Luttmer 2005).

Clark and Oswald (1998) developed a mathematical model showing that rational agents who care about relative outcomes (and are risk-averse with regards to the comparison) will match the strategies of other agents. DeMarzo, Kaniel, and Kremer (2005) applied this idea specifically to a financial market context and established that relative wealth concerns could lead rational players to participate even in a finite-horizon (i.e., irrational) bubble. Isaac and James (2003) demonstrated that when payment in an experimental asset market is explicitly linked to above-average performance, the logic of the game changes such that bubbles are rational outcomes, and, empirically, they are not eliminated by experience.

> Hypothesis 3: The tendency to use a complementary strategy is accentuated when relative performance is made more salient

The remainder of this paper reports four studies testing the above three hypotheses, followed by discussions of how the hypotheses taken together can explain behavior in the asset market experiment. I conclude with the implications for real-world markets.

Study 1: The Penny Jar Game

Study 1 was designed to test Hypothesis 1 that *people are more likely to match the strategies used by others when the object of judgment is the opinion of others than when it is an objective value*.

Participants for all four studies reported in this paper were recruited from the student population at a large research university via a combination of posters and e-mails. The four studies had similar demographic profiles, as shown in Table 1 (note that Studies 1 and 3 were conducted in the same session).

Table 1
Study Demographic Profiles

	Gender	Age			
	% Male	Average	Median	Minimum	Maximum
Study 1/3	46.9	22.9	21	18	37
Study 2	52.4	24.1	21	18	59
Study 4	42.9	23.4	20	18	59

In Study 1, subjects participating in 16 groups of 3 to 5 (N=59) first individually guessed the number of pennies in two jars marked Jar A and Jar B. Following a filler task, they were given a sheet of paper with the following instructions:

> Everyone who participates in this experiment will have two chances to win additional money (we expect approximately 100 participants in total).
> - In Contest 1, the winner will be the person who guesses closest to the **actual number of pennies in Jar A**. If two guesses are equally close, the winner will be the person with the higher guess.
> - In Contest 2, the winner will be the person who guesses closest to the **average of all participants' guesses of the number of pennies in Jar B**. If two guesses are equally close, the winner will be the person with the higher guess.

Before making a final guess for each contest, subjects were reminded of their initial guess for each jar and also given the average of all the guesses for each jar among the members of their experimental group.

Study 1 Results and Discussion

"Strategies" in the Penny Jar Game are extremely simple: each player has their own individual initial estimate of the number of pennies in the jar and is also given the average estimate for all players in their group, so that strategy essentially consists of deciding on the relative weight to assign each of these two estimates in making a final estimate. The "weight of advice" (WOA) measure has been employed in several studies (Yaniv 2004) to measure the extent to which a decision maker utilizes advice (in this case, the group average) in revising a judgment. Calculated as (Final Estimate – Initial Estimate)/(Advice – Initial Estimate), a WOA greater than 0.5 indicates a greater reliance on the advice than on one's own initial opinion (a weight of 1 indicating that the advice has been completely adopted), while a WOA less than 0.5 indicates a greater reliance on one's own initial opinion than on the advice (a weight of 0 indicating that the advice has been completely ignored).

WOA analyses generally assume that the final estimate falls between the initial estimate and the advice, so that the WOA is not less than 0 nor greater than 1. In Study 1, 28.8% (17/59) of subjects had at least one WOA for which this was not true. In the case of 3 subjects, this was because the subject's initial estimate for Jar A was the same as the group average, thus allowing no conclusions about how subjects were influenced by the group "advice." The remaining 14 subjects with WOAs outside the standard interval consisted of the following:

- 11 subjects with at least one WOA greater than 1 (i.e., these subjects moved from their initial guess past the group average): 6 for Jar A, 3 for Jar B, and 2 for both Jars
- 2 subjects with at least one WOA less than 0 (i.e., these subjects changed their guess in the opposite direction from the group average): 1 for Jar B and 1 for both Jars
- 1 subject with WOA greater than 1 for Jar A and less than 0 for Jar B

There are several reasons why subjects' might have behaved in this apparently illogical manner. First, the initial judgment was elicited without any explicit indication of its purpose, while the final judgment was elicited in the context of a monetary contest. Thus, subjects may have exercised greater care in making final estimates. Second, the fact that subjects knew that there would be only one winner in each contest, with a bias towards a higher number, may have induced strategic reasoning in a number of subjects. 11 of the 14 WOAs greater than one resulted from a guess that was between 100% and 110% of the group average, suggesting that in many cases people were simply trying to slightly overshoot the group average. For example, one subject with WOAs greater than 1 for both jars had initial guesses of 300 and 400, group averages of 462.5 and 537.5, and final guesses of 475 and 550 for Jar A and Jar B, respectively.

Because of the difficulty of interpreting WOAs less than 0 and greater than 1, I performed analyses on both the full data set (N= 56, excluding the three subjects with initial guesses equal to the group average for Jar A) and on a subset of the data excluding subjects with either WOA less than 0 or greater than 1.1 (N=46). Consistent with Hypothesis 1, the average WOA for the full data set was 0.38 for Jar A (guessing the actual number of pennies) and 0.56 for Jar B (guessing the average of all the guesses) (Paired, one-tailed t-test: t=-2.01 on 55 degrees of freedom, $p<0.05$). For the subset of the data, the results were essentially the same, i.e., average WOA was 0.37 for Jar A and 0.51 for Jar B (Paired, one-tailed t-test: t=-3.01 on 45 degrees of freedom, $p<0.01$). To avoid the potential distortion from outlier WOAs, I also performed a Wilcoxon signed-rank test on the full data set (V=206, $p<0.05$).

Thus, Study 1 supports the hypothesis that people are more likely to match the strategies (guesses) of others when the task is estimating group opinion than when the task is estimating objective fact. It is worth noting that subjects were correct to rely more heavily on group opinion when the object of judgment is group opinion itself: for 55% of the subjects, the average of their group's guesses were closer to the overall average guess than their individual guesses for both jars, while individual guesses were better than the group average for both jars for only 25% of the subjects (the remainder had a better individual guess for one jar and a better group guess for the other). But subjects ought to have also relied more heavily on group opinion when the object of judgment is an objective fact: for 49% of the subjects, the average of their group's guesses were closer to the overall average guess than their individual guesses for both jars, while individual guesses were better than the group average for both jars for only 36% of the subjects.

Study 2: The Lottery Game

Study 2 was designed to test Hypothesis 2 that *the value an individual assigns to a risky asset is influenced by the opinions of others*. In the Lottery Game, subjects playing in groups of between 2 and 5 people (N=84 in 23 groups) first filled out some questionnaires, for which they were paid with a combination of cash and a ticket to play a gamble with 4 equally probable outcomes (0, \$0.80, \$2.40, and \$6.00), with the outcome determined by drawing a slip of paper from a bag containing one slip for each possible outcome. These payoffs were chosen to be similar to the payoffs of the asset used in most experimental asset markets (including those reported in Study 4).

Individual buying and selling prices were elicited for the tickets from each subject by using a titrated "BDM" procedure (Becker, Degroot and Marshak 1964). Specifically, subjects were told that the experimenter would sequentially pull two slips of paper out of a bag and offer to buy their ticket for the amount on the first slip, or sell them an additional ticket for the amount on the second slip. They were told that there were 8 slips ranging from \$0.60 to \$3.75 in \$0.45 increments and were asked to decide for each possible value that could be drawn from the bag

- whether they would be willing to sell their ticket and receive that dollar amount or would prefer to keep their ticket and play the gamble (willingness to accept, or "WTA")

- whether they would be willing to buy another ticket for that dollar amount in order to play the gamble a second time (willingness to pay, or "WTP")

The order in which WTA and WTP was elicited was counterbalanced.

After expressing their initial preferences, subjects were given a second ticket to play the same game and told that they had to reach a binding consensus among all members of the group on WTA for that ticket (leaving unaffected their decisions for the first ticket, which had not yet been resolved). 100% of groups were able to agree on consensus prices. They were then told that the group decision would not be implemented and they could decide their own individual WTA for the second ticket. After this, the BDM procedure was implemented for the second lottery ticket and the gamble was resolved.

Study 2 Results and Discussion

Study 2 generated three data points for each subject: individual initial price, group consensus price, and individual final price (following group discussion). A logical consequence of the hypothesis that individual prices are influenced by the group consensus is that subjects will be more likely to change the price they assign to the asset following exposure to the group consensus if their initial price was different from the group consensus than if it was the same. As predicted, 13.0% (3/23) of subjects whose initial price was the same as the group consensus changed the price they assigned after group discussion compared with 83.6% (51/61) of those whose initial price was not the same ($p<0.001$ for one-tailed $\chi^2_{(1)}$ test comparing the differences in proportion of subjects changing vs. not changing their price). Furthermore, 92.2% of those whose initial price was not the same as the group consensus who changed their price changed in the direction of the group consensus, supporting the assertion that they were shifting in the direction of the social norm (this assertion is further supported by the positive coefficients in the regression analysis reported below).

This analysis, however, leaves open the possibility that the influence of others in these studies is merely a proxy for a purely informational influence. Since subjects are not merely exposed to the consensus price, but are also exposed to a group discussion from which the consensus emerges, they might be changing the price they have assigned to the asset not because they are matching the preferences of others, but because they have learned some useful information that helps them to better understand their own preference. In particular, most of the conversations touched upon the concept of expected value, which was neither explained nor provided to subjects by the experimenter, and in many cases the change from initial preference to final preference was in the direction of expected value. Perhaps, then, subjects are not changing their price to match the group consensus, but changing their price in the direction of expected value.

One approach to distinguishing these two influences is to compare the behavior of subjects whose initial price was equal to the group consensus with those whose initial price was equal to expected value. If group consensus is more influential in price changes, we would expect that those whose initial price was equal to group consensus would be less likely to change their price than those whose initial price was equal to expected value. Excluding those instances when the group consensus was the same as expected value (since they do not allow us to discriminate between these two alternative influences), 0% (0/10) of subjects whose initial price was the same as group consensus changed their price after group discussion vs. 40.0% (4/10) of subjects whose initial price was the same as expected value ($p<0.05$ for one-tailed $\chi^2_{(1)}$ test). Furthermore, 47.2% (17/36) of subjects whose initial price was *not* the same as group consensus changed their final price to the group consensus exactly while only 6.1% (2/33) of those whose initial price was *not* the same as expected value changed their final price to expected value exactly ($p<0.001$ for one-tailed $\chi^2_{(1)}$ test).

Finally, the effect of social influence is also demonstrated by a reduction in (normalized) standard deviation from 0.34 for initial prices to 0.23 for final prices, a natural consequence of convergence to the social norm.

The greater influence of social as compared to objective information is further supported by comparing alternative regression models to predict an individual's change in preference from initial to final price either from the difference between a subject's initial price and the group consensus price or from the difference between a subject's initial price and expected value ("Group" and "EV", respectively, in Table 2). Seven subjects initially declined to sell at any of the stated prices, while only a single subject did the same after group discussion. Since the independent variable is the magnitude of the change from initial to final price following group discussion, a conservative approach to coding these subjects was to record their WTA as one increment beyond the highest category (i.e., they were coded as having a WTA of $4.20), since this minimized the extent of any post-discussion shift.

The two middle columns of Table 2 titled "Group" and "EV' show the single-factor regression models. One can see that both factors explain a considerable amount of the variance in the data sets. Note, however, that the intercept in the EV model is significantly different from 0, while the intercept in the Group model is not. The first column, titled "Group/0," shows the regression for the Group factor where the intercept is constrained to be 0, which does not meaningfully alter the parameter values, including the percentage of variance explained. The equivalent model for EV is not shown, because it results in no significant parameters.

The zero-intercept model makes theoretic sense because it suggests that final price can be predicted by a simple weighted average of initial price and social consensus price, with the regression coefficient corresponding to the relative weight placed on the social consensus. Thus, the average subject adjusted their price approximately three-quarters of the way towards social consensus.

Table 2
Predicting (Final Price – Initial Price)
Lottery Game WTA (N=84 in 23 groups)

Factors	Group/0	Group	EV	Combined
Intercept	-	-0.02 (0.02)	-0.94 (0.09)*	-0.06 (0.20)
Group consensus - Initial price	0.77 (0.06)*	0.76 (0.06)*	-	0.72 (0.15)*
Expected value - Initial price	-	-	0.69 (0.07)*	0.04 (0.15)
% variance explained	0.65	0.65	0.55	0.65

* p<0.001
Standard Errors in parentheses;
% variance explained is relative to the null model y=mean(y)

By contrast, the non-zero intercept in the EV model rules out a weighted average model for initial price and EV. The two-factor model combining both variables ("Combined") reinforces the superiority of deviation from group consensus as an explanatory variable: variation from group consensus is significant (p<0.001) while variation from expected value is not. Note that the use of expected value in the regressions is merely a choice of parameterization based on the idea that this is the most obvious piece of exogenous information, so that a weighted average model driving price toward expected value was plausible. The regression models fit equally well for any difference of initial price from a constant.

Though Study 2 provides support for the hypothesis that the price that individuals assign to a risky asset is influenced by the price that others assign, and that this influence is due more to social than to informational reasons, the statistical power of all the tests performed was constrained by the fact that for nearly half of the subjects, the group consensus was the same as expected value, limiting the ability to distinguish between their respective influence. Furthermore, the experiment only tested the impact of the group on WTA. Study 3 was designed to address both of these issues.

Study 3: The Dice Game

Study 3 used a procedure similar to Study 2, but asked subjects to price a higher variance gamble that was predicted to be less likely to result in a group consensus equal to expected value. In the Dice Game, subjects playing in groups of between 2 and 5 (N=59 in 16 groups), first filled out some questionnaires, for which they were paid with a combination of cash and a ticket to play a gamble with 4 possible outcomes determined by rolling a pair of dice: players would receive $30 for a roll of 2 or 12, $5 for a roll of 3 or 11, $2 for a roll of 4, 5, 9 or 10, and 0 for a roll of 6, 7 or 8. Players were provided with a chart (Appendix A) that showed the frequency distribution of each possible payoff and calculated the expected value of the gamble ($3).

As in Study 2, initial individual buying and selling prices for the tickets were elicited from each subject by using a titrated "BDM" procedure (Becker, Degroot and Marshak 1964). In the Dice Game, the slips of paper used to determine buying and selling prices for the gamble consisted of 7 values ranging from \$0.50 to \$3.50 in \$0.50 increments. To address the Lottery Game's lack of precise WTP and WTA for those unwilling to buy or sell at any of the stated prices, these subjects were asked to provide a maximum WTP or a minimum WTA, respectively.

After expressing their initial preferences, participants were told that instead of using their initial preference, they would need to reach a binding consensus among all group members on both WTA and WTP. 100% of groups were able to agree on consensus prices. Following these two (counterbalanced) group discussions, participants were then told that the group decisions would not be used and they would have one final opportunity to decide their own individual WTA and WTP. Immediately afterward, the BDM procedures were implemented and the gambles were resolved.

Study 3 Results and Discussion

Study 3 generated two data sets for each subject, one for WTA and one for WTP, each consisting of three data points: individual initial price, group consensus price, and individual final price. Three subjects who were willing to pay more for the gamble (WTP) than they needed to get to sell it (WTA) were excluded from the analyses below because of concerns that they may not have fully understood the instructions (including these subjects, however, did not alter the pattern of results). The greater skewness in potential outcomes in the gamble in Study 3 as compared to Study 2 had the predicted effect only in the case of WTP: whereas 48.8% (41/84) of subjects in Study 1 were in groups where consensus WTA was equal to expected value, this was only true of 4.9% (2/56) of subjects in Study 3 in the case of WTP, and 48.2% (27/56) in the case of WTA.

Consistent with the results of Study 2, 18.2% (2/11) and 0% (0/9) of subjects whose initial WTA or WTP, respectively, was the same as the group consensus changed the price they assigned after group discussion compared with 53.3% (24/45) and 72.3% (34/47) of those whose initial price was not the same ($p<0.05$ and $p<0.001$ for one-tailed $\chi^2_{(1)}$ tests for WTA and WTP, respectively).

Also consistent with the results of Study 2, excluding those instances when the group consensus was the same as expected value, 20.0% (1/5) and 11.1% (1/9) of subjects whose initial WTA or WTP, respectively, was the same as group consensus changed their price after group discussion vs. 60.0% (3/5) and 66.7% (6/9) of subjects whose initial price was the same as expected value (n.s. and $p<0.05$ for one-tailed $\chi^2_{(1)}$ tests for WTA and WTP, respectively; $p<0.01$ for the combined data set). Furthermore, 16.7% (4/24) and 23.9% (11/46) of subjects whose initial WTA or WTP, respectively, was *not* the same as group consensus changed their final price to the group consensus exactly while only 11.5% (3/26) and 2.2% (1/46) of those whose initial price was *not* the same as expected value changed their final price to expected value exactly (n.s. and $p<0.01$ for one-tailed $\chi^2_{(1)}$ tests for WTA and WTP, respectively; $p<0.01$ for the combined data set).

Thus, the two data sets of Study 3 and the one data set of Study 2 all show a pattern consistent with Hypothesis 2, that the value an individual assigns to a risky asset is influenced by the opinions of others, more for social than informational reasons:

- subjects are likelier to change their price following group discussion if their initial price was different from the group consensus than if it was not
- subjects are likelier to change their price if their initial price is different from the group consensus than if it is different from expected value
- subjects are likelier to change their price exactly to the group consensus than exactly to expected value

Finally, the same regression models used in Study 2 were applied to the Study 3 data sets. In the case of WTP, the model which predicts an individual's change in preference from initial to final price from the difference between a subject's initial price and the group consensus price is superior to one which uses the difference between a subject's initial price and expected value ("Group" and "EV", respectively, in Table 3). The two models work equally well in the case of WTA, perhaps for reasons related to the much higher percentage of groups with a consensus price of expected value, which makes it more difficult to disentangle the two possible sources of influence. Nevertheless, while this result fails to reconfirm the greater role of non-informational imitation, it does not contradict it, and is consistent with the influence of imitation in general.

Table 3
Predicting (Final Price – Initial Price)
Dice Game WTA (N=56 in 16 groups)

Factors	Group/0	Group	EV	Combined
Intercept	-	-0.10 (0.16)	-0.06 (0.16)	-0.06 (0.16)
Group consensus - Initial price	0.49 (0.08)*	0.46 (0.09)*	-	-0.13 (0.35)
Expected value - Initial price	-	-	0.46 (0.08)*	0.57 (0.32)
% variance explained	0.31	0.32	0.35	0.36

Dice Game WTP (N=56 in 16 groups)

Factors	Group/0	Group	EV	Combined
Intercept	-	-0.02 (0.06)	-0.61 (0.11)*	0.08 (0.17)
Group consensus - Initial price	0.63 (0.06)*	0.63 (0.06)*	-	0.72 (0.15)*
Expected value - Initial price	-	-	0.56 (0.07)*	-0.10 (0.15)
% variance explained	0.67	0.67	0.53	0.67

* p<0.001
Standard Errors in parentheses
% variance explained is relative to the null model y=mean(y)

Thus, the average subject adjusted their price approximately half of the way towards the social consensus for the Dice Game WTA and two-thirds of the way towards the social consensus for the Dice Game WTP, and, as in Study 2, this convergence to the social norm is reflected in a reduction in (normalized) standard deviation from initial to final prices from 0.56 to 0.47 for WTA, and from 0.37 to 0.26 for WTP.

In summary, the data support the hypothesis that the price that individuals assign to a risky asset is influenced by the price that others assign, due more to social than to informational influence. Prices converge towards the group consensus price, which is often, but not always, expected value. In other words, price emerges from a social consensus and thus is endogenous to the pricing system, as opposed to the standard model that price is determined exogenously.

Study 4: The Stock Market Game

Study 4 was intended to test Hypothesis 3, that *the tendency to use a complementary strategy is accentuated when relative performance is made more salient*.

Subjects participated in 12 groups of 8 to 10 players each (N=113; due to technical problems, 3 of the groups, comprising a total of 28 subjects, did not complete the experiment) in an experimental asset market in which participants traded a stock-like asset (Smith, Suchanek, and Williams 1988). The market had 15 three-minute trading periods during which participants could buy and/or sell shares of the stock. At the end of each period, each share paid a dividend in cash, determined by a computerized random draw from four equally probable values (0, $0.08, $0.28 or $0.60). Subjects were initially endowed with one, two or three shares of the asset plus a cash account of $9.45, $5.85 or $2.25, respectively, so that all participants began with the same expected value payoff ($13.05). At the end of the experiment, participants were paid an amount of money equal to their starting cash account plus the total value of the dividends they received plus any amounts received from sales of shares, less any amount paid for purchases of shares.

Subjects played the game on computer terminals in separated individual cubicles. Before commencing play, subjects were given extensive oral instruction (Appendix C) in the use of a multiple unit double auction market process (Plott and Gray 1990) programmed and conducted with the software Ztree (Fischbacher 2007), using an interface developed by Haruvy and Noussair (2006). Subjects were also given a reference sheet that showed the expected value of each share at the beginning of each trading period, along with an explanation of how it was calculated (Appendix D). Subjects next played a two-round game to practice and experience the trading process (see Appendix E for an example of the trading screen). Finally, their accounts were reset to their initial values and the actual game commenced.

Immediately following each round of the game, subjects viewed a screen (Appendix F) which included the following information about their account:

- current cash account (C)
- current number of shares held (S)
- account total = C + (S x highest "bid" made for a share in this period)

The only manipulation that differed between markets was the type of information available for social comparison. Research on social comparison processes has indicated that people are likelier to engage in upward comparison when they want to improve their performance, but are likelier to engage in downward comparison when they want to enhance their self-image (Taylor and Lobel 1989). Though this research demonstrates how motivation affects information search, I hypothesized that causality could also run in the opposite direction, and that providing upward comparison information would be more likely to influence motivations regarding relative outcomes, relative to providing downward comparison information. Thus, in five completed markets (the "upward" groups), subjects also saw the highest account value of any player in the game, while in the other four completed markets (the "downward" groups), subjects instead saw the lowest account value of any player in the game

Payment for participation consisted of a $5 show-up fee plus the value of the subject's cash account at the end of the game. Final payments (including the show-up fee) ranged from a high of $73.55 to a low of $5.00. The average payoff was $18.72, and the median payoff was $13.77.

<u>Study 4 Results and Discussion: Influence of Social Comparison</u>

Figures 1 and 2 show average trading price for the asset during each of the 15 periods of the game for the five completed upward markets and four completed downward markets, respectively. The straight, downward-sloping line represents the expected value of the asset during each period. Consistent with prior research studies (Porter and Smith 2003), the results offer no support for EMH, which predicts that trading prices for the asset in the Stock Market Game (assuming that subjects are risk neutral) should closely track the expected value of the remaining dividends (i.e., $0.24 times the number of periods remaining). Rather, there is as a strong tendency for prices to manifest a bubble (i.e., they exceed expected value for a large portion of the game). In fact, all of the upward markets here show considerable bubbles.

The game's wide range of payoffs meant that players in the upward markets were made aware that at least one player was pursuing a very successful strategy -- the average value of the highest account across all periods of all upward markets was $45.22. This success was especially accentuated during a bubble, when the use of market price in valuing shares ascribed a high notional value to those shares. Players in downward markets, by contrast, were only aware that a player in the game was using a very bad strategy -- the average lowest account across all periods of all downward markets was $2.10.

Figure 1
Average Trading Price for Upward Games

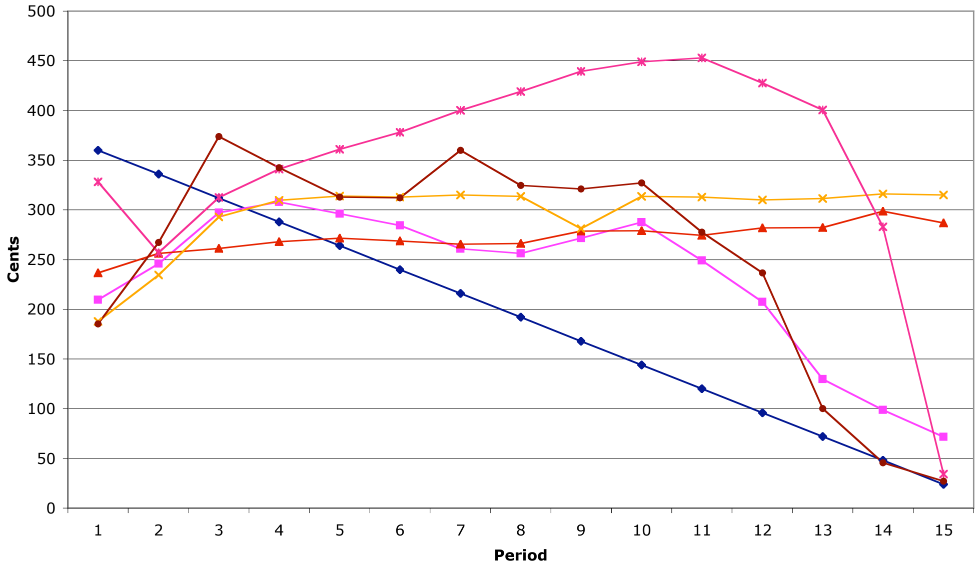
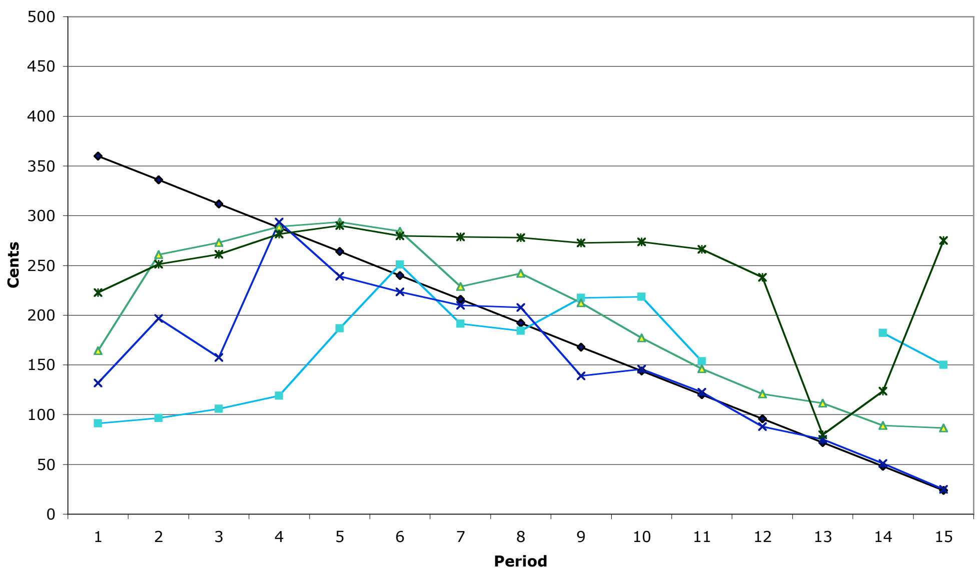


Figure 2
Average Trading Price for Downward Games



A visual comparison of Figure 1 with Figure 2 suggests that providing upward comparison information increases the likelihood and accentuates the magnitude of bubbles. Table 4 provides a comparison of the two types of markets on a number of standard metrics used to test for the size of bubbles:

- Price amplitude: a measure of the magnitude of overall price changes relative to the fundamental value over the life of the asset, it is defined as $\max_t\{(P_t-f_t)/f_t\} - \min\{(P_t-f_t)/f_t\}$ where P_t and f_t equal the average transaction price and fundamental value in period t, respectively.
- Turnover: a normalized measure of the amount of total trading activity in the market, it is defined as $(\sum_t q_t)/TSU$ where q_t is the quantity of units of the asset exchanged in period t and TSU is equal to the total stock of units (in Study 4, 2 times the number of participants in a given market)
- Normalized absolute deviation: a measure that includes both transaction prices and quantities exchanged, it is defined as $\sum_t\sum_i|P_{it}-f_t|/(100*TSU)$ where P_{it} is the price of the *i*th transaction in period t.
- Average price: the average price of all transactions in a given market
- Maximum deviation: the maximum difference between a given period's fundamental value and the average trading price for that period, it is defined as $\max_t\{(P_t-f_t)\}$

Consistent with the visual evidence, the upward markets have higher average values on every one of these metrics, though the differences between the two types of market are only significant in the case of average price (one-tailed t-test: t=-2.77 on 5.695 degrees of freedom, $p<0.05$) and maximum deviation (one-tailed t-test: t=-2.05 on 5.535 degrees of freedom, $p<0.05$), the metric identified by Caginalp, Porter, and Smith (2001) as the most important for evaluating the impact of situational manipulations on bubble magnitude. Nevertheless, given the small number of markets in each condition, further research will be needed in order to demonstrate the replicability of this effect.

Table 4
Measures of extent of "bubbles"

	Price Amplitude	Turnover	Normalized Absolute Deviation	Average Price	Maximum Deviation
	(Dimensionless)			(In cents)	
Upward Markets					
Market 1	2.4	10.3	9.0	245.59	143.50
Market 4	11.3	6.6	9.1	265.32	262.87
Market 8	12.6	16.2	16.3	283.00	291.20
Market 10	5.1	10.9	17.5	351.54	333.13
Market 12	2.0	8.9	11.5	253.52	183.25
Upward Average	**6.7**	**10.6**	**12.7**	**279.79**	**242.79**
Downward Markets					
Market 3	6.0	5.8	10.7	140.60	134.00
Market 6	3.2	8.8	7.3	222.36	62.67
Market 7	0.7	15.1	13.0	145.50	15.71
Market 9	10.8	5.6	5.9	246.25	251.00
Downward Average	**5.2**	**8.8**	**9.2**	**188.68**	**115.85**

Study 4 Results and Discussion: Determining the "Nature of the Task"

Caginalp, Porter and Smith (2001) offer the following model to explain the typical bubble pattern observed in asset market experiments: "an initially undervalued price spurs buying from the value-based sentiment. This creates an uptrend that eventually induces momentum, creating a sentiment to buy even after prices have exceeded the fundamental value and despite some selling by the value-based investors" (p. 81).

Though this explanation is consistent with the observed pattern, it does not explain the underlying reasons for the initial undervaluation and the resulting momentum belief. In addition, it fails to explain the unusual pattern observed in three of the markets in Study 4, where price fails to collapse at the end of the experiment. I argue that these phenomena can all be understood by considering the alternative ways in which subjects might construe the nature of their task.

First, why are prices in the initial periods of the Stock Market Game so low? Recall that in the Lottery Game (Study 2), subjects were asked to price a gamble with payoffs proportionate to those of the asset in the Stock Market Game. The average price which people were initially willing to pay to buy the gamble was 57.8% of its expected value, while the average price at which they were initially willing to sell the gamble was 116% of expected value. By creating supply and demand curves from the individual values of WTA and WTP, we can calculate the market clearing price in the Lottery Game, i.e., the price at which there would be an equal number of buyers willing to pay that amount or more and sellers willing to sell for that amount or less. The market clearing price for initial valuations is 100% of expected value, with 14 willing buyers and sellers, or 16.7% of the total number of buyers and sellers.

By contrast, across all markets in Study 4, the average trading price of the asset in Period 1 was $1.73, or 48.1% of expected value (N=360 trades in 12 markets, representing 211.8% of the 170 total shares in these markets). Thus, the average Period 1 trading price is not only substantially lower than both average WTA and the imputed market clearing price in the Lottery Game, but is even lower than average WTP. This is puzzling given that past research demonstrates that people are likelier to accept multiple plays than a single play of a gamble (Benartzi and Thaler 1999), implying they ought to ascribe a higher price to the asset in the Stock Market Game, which pays a dividend 15 times, than in the Lottery Game, which only pays once.

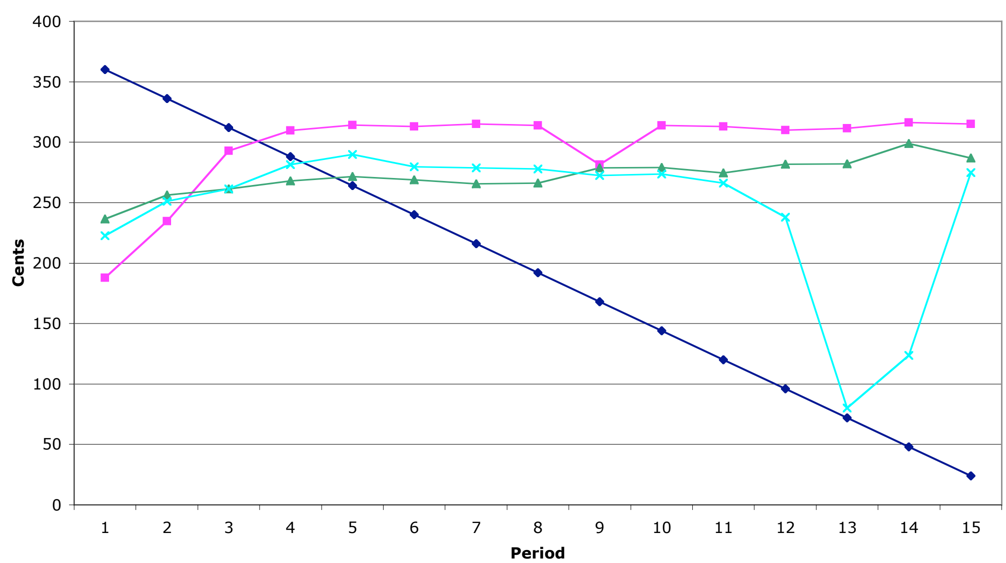
I propose that the higher trading volumes and lower valuations of the asset in the Stock Market Game are the result of a greater degree of uncertainty in the subject population about "the nature of the task." In the Lottery Game, it is presumably clear to subjects that the nature of the task is simply to determine the price at which they are willing to buy and sell the asset based on their own risk preferences. In this situation, the low hypothetical volume of trades (i.e., the small degree of overlap between buying and selling prices) is logically attributable to the endowment effect (Kahenman, Knetsch, and Thaler 1991), which causes subjects to typically have a significantly higher WTA than WTP even though from an economic perspective these two prices ought to be nearly identical.

But in the Stock Market Game, the existence of a resale market creates ambiguity about the nature of the task. One consequence is a remarkably high volume of trades in the early periods of the game: more than double the total number of shares. This is clearly higher than can be explained solely by the rational expectations model of trading, where the only trades would result from more risk averse subjects with large initial stock endowments selling shares to less risk averse subjects with small initial stock endowments. The high volume of trades in Study 4, which is consistent with high volumes seen in past laboratory asset market research, supports a hypothesis offered by Lei, Noussair, and Plott (2001) that experimental asset market bubbles are in part due to a demand effect: participants, having received extensive training in how to trade, and offered no alternative activity to engage in during the course of the experiment, conclude that the "nature of the task" is active trading rather than maximizing payoffs.

A second consequence of uncertainty about the nature of the task is ambiguity as to whether prices should only reflect one's own preferences or should also factor in the preferences of others. Research has demonstrated that people are averse to ambiguity and seek to avoid risks associated with situations in which probabilities are unknown (Camerer and Weber 1992), so that uncertainty about the basis upon which the asset ought to be valued might explain the low prices in early periods of the market.

In other words, in a social setting, people are looking to each other for cues about the "nature of the task." The absence of such cues at the beginning of the game leads people to place lower values on the object of judgment – here, the risky asset -- until they have a better sense of what is going on. This idea also provides a possible explanation for three markets where prices failed to crash at the end of the experiment (Figure 3).

Figure 3
Average Trading Price in Markets Where Price Fails to Collapse(Markets 4, 8 and 9)



Recall that subjects were given oral instructions at the beginning of the game that made clear that the shares were worthless at the end (Appendix C), and were also given a written sheet showing the remaining expected dividend at the beginning of each period of the game (Appendix D). Yet in the final period of the game in each of these three markets, multiple buyers were paying prices ranging from $2.50 to $3.19, while in another three markets, a single individual also paid anywhere from $1.00 to $1.50. Thus, in six of the nine completed markets, at least one and as many as seven players bought shares for more than their maximum possible value in Period 15 ($0.60).

Clearly a number of subjects misunderstood or forgot the rules of the game. Market 4 was the first and most severe instance of this confusion: here, seven of the ten players paid prices ranging from $2.80-2.90 in fifteen trades in the game's final period. Observing this result made me sufficiently concerned about inadequate instructions that I rewrote the instructions in order to emphasize three times that the shares would be worthless at the end. Nevertheless, the problem recurred to a smaller degree in Markets 8 and 9; in each market, two players paid prices ranging from $2.50-3.19 in multiple transactions in the final round of the game.

Why did so many subjects make this mistake? Even if people did not recall that shares were worthless at the end of the game, what did they think they would receive for them? An unusual feature of my experimental protocol suggests the answer: in order to test Hypothesis 3, at the end of each period of the Game, subjects were informed of the "Stock Price," defined as the best bid in the period just completed (see Appendix F for an example of the status screen seen by participants), which was used in calculating players' current "Account total". The most plausible explanation for the willingness of some subjects to pay more than the asset was worth is that they came to believe that the "Stock Price" represented the actual value of the shares. In other words, while the typical bubble pattern can be explained by a belief that the nature of the task is *forecasting* average opinion, these subjects came to believe that average opinion actually defined the value of the asset!

Consider the game from the participants' point of view. The instructions at the beginning of the experiment are long and complicated; along with the game's basic structure, players must also learn to use unfamiliar computer-based trading software. In the absence of any explanation as to why the Stock Price is being given, it is not surprising that some subjects, assuming the information must be relevant in some way, either forget the initial instructions or wonder whether they misunderstood them.

This confusion is likely reinforced by the observation that *other* people seem to also place a high value on the asset, which Study 2 indicates will influence the price individuals will ascribe to the asset themselves. Figures 4, 5, and 6 show the complete trading history for Markets 4, 8 and 9, respectively. Note that in each case, there are initially wide fluctuations in the market price, but once multiple trades have occurred at approximately expected value, these fluctuations are substantially diminished, and further trading, with only a few exceptions, occurs within a narrow band.

Figure 4
All Trades Market 4

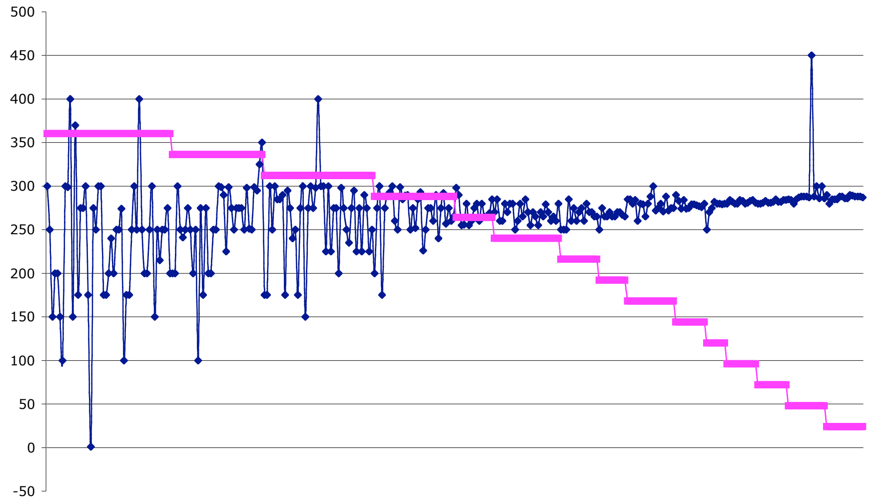


Figure 5
All Trades Market 8

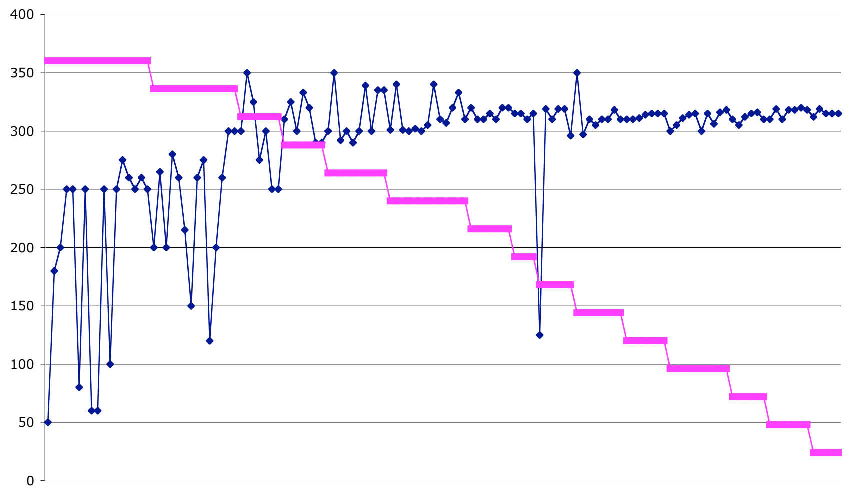
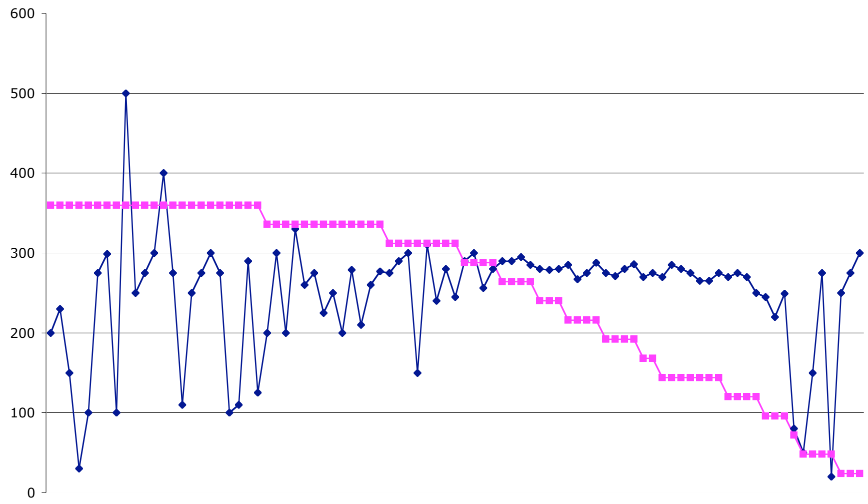


Figure 6
All Trades Market 9



The decreasing fluctuations in price as a consensus gets established thus directly parallel the reduced variation in prices following group discussion in Studies 2 and 3. The power of this social norm constrained trading within a narrow band until the very end of the game, suggesting that the norm was strong enough to cause players to forget or ignore the game's rules. The odd finale of Market 9 (Figure 6) can be understood in this context: despite a collapse in trading price in Period 13, presumably representing the triumph of rational forces over imitation-based inertia, enough traders still believed in the validity of the prior social norm to drive the price back to that level at the end of the game.

The unusual pricing patterns in these markets provide evidence that "momentum sentiment" represents merely one form of a more general phenomenon that results from players "anticipating what average opinion expects the average opinion to be." Imagine the following thought experiment: suppose one were to run a second round of the Penny Jar Game (Study 1) using the Jar B criteria, where a reward goes to the person guessing closest to the average of all guesses (note that this is effectively an unbounded Beauty Contest (Camerer and Fehr 2006) with a multiplier of 1). Given the results of Study 1, it seems likely that if subjects were given the average for *all* subjects in the first round of the game, they would weight this number even more heavily than the approximately 56% weight they apply to the average guess within their smaller group. Repeated rounds of the game therefore ought to result in a pattern very similar to that observed in Figures 4-6: fluctuations around some central point which diminish over time. Once the average has stabilized at some number, no player has any incentive to deviate from that average guess.

Now consider a small variation in the game where the reward is given to the person who is one number above the overall average guess. In this case, the best response to the result from the last game is to guess slightly higher than the previous average. This process is directly analogous to "momentum sentiment," since equilibrium in this circumstance would be an unbounded process where the average guess increases ad infinitum. (Note that though a bias towards a higher guess was also present in Study 1, in that case the higher guess would only win if there was a tie, so that the best response to the prior average if everyone else is guessing the prior average would be to guess the prior average exactly, since it does one no good to be slightly higher than everybody else.)

A critical reason that this small variation creates an unbounded momentum-based equilibrium is that though the notional starting point in either version of the contest is the number of pennies in Jar B, that exogenous value is ultimately irrelevant in determining the winner. Rather, the number of pennies in the jar serves solely as a focal point for players' initial guesses. Focal points, an important element in the theory of coordination games (Schelling 1960), are closely related to the concept of "sunspot equilibria" (Cass and Shell 1983), economic equilibria which depend on extrinsic random variables (sunspots) which matter only because people think they matter. The concept of complementary strategies, the central theme of this paper, was in fact first developed in studies of coordination games (Cooper 1999), suggesting that coordination games offer a potentially useful model for thinking about behavior in the asset market experiments.

Consider the complete record of trades in Market 7 (a "downward" market, Figure 7), where price tracks expected value extremely closely from Period 4 onwards. EMH advocates would argue that this is because players have learned to price the asset at expected value. From the perspective of a coordination model, however, it would be equally true to assert that expected value serves the sunspot function here, and that price stabilizes at expected value because players believe that *other* participants will price it at expected value. By contrast, in Market 12 (an "upward" market, Figure 8), a large number of trades in periods 5-10 follow an intriguingly stable upward pattern consistent with "momentum sentiment", which a coordination model would explain by reference to the momentum belief itself as serving as a sunspot.

Figure 7
All Trades Market 7

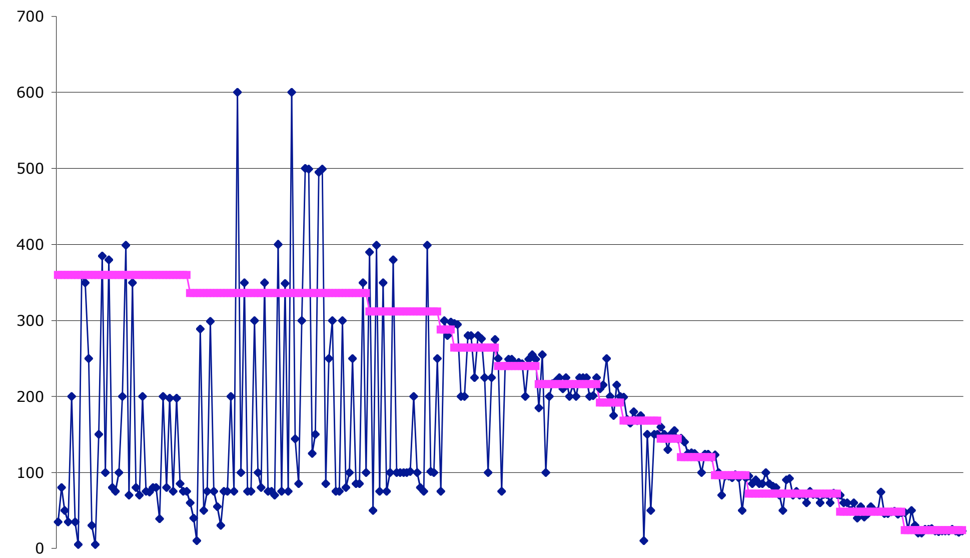
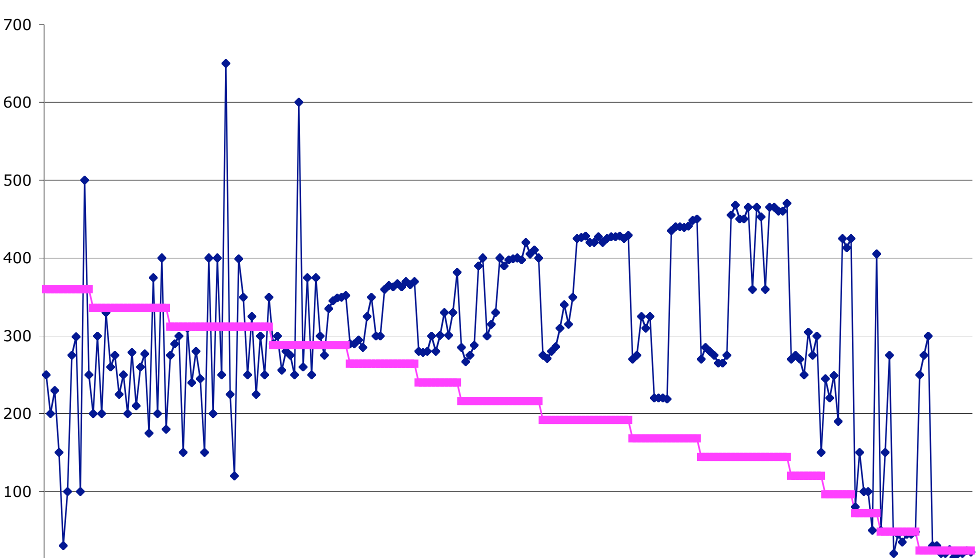


Figure 8
All Trades Market 12



Why do momentum beliefs offer a focal point? Morris, Sheldon, Ames and Young (2007) found that individuals are likelier to predict the continuation of a price trend when the trend is described using verbs denoting agentic action, i.e., via metaphors that imply that the market is an animate agent. Thus, it may be that the process of trying to anticipate average opinion entails employing a conceptual schema of the group as a purposeful entity, which results in predictions of trend continuation.

General Discussion

Fehr and Tyran (2005) suggest that the debate about the efficiency of markets is "essentially a debate about whether the actions of 'smart' traders and 'noise' traders are strategic substitutes or complements" (p. 63). They, like Camerer and Fehr (2006) and Shleifer and Vishny (1997), counter the argument of EMH advocates that the substitution strategy of arbitrage will prevail by pointing out that real-world arbitrage is not, in fact, riskless, and enumerate several risks faced by arbitrageurs that might cause them to rationally avoid the use of substitution strategies.

These papers, however, focus on negative arguments against the use of substitution strategies rather than positive arguments in favor of the use of complementary strategies. The goal of the research program presented here is to ask what is it about the strategic environment of financial markets that provides incentives for matching the strategies of others.

I have argued that the answer lies in Keynes' suggestion that market participants are focused more on "anticipating what average opinion expects the average opinion to be" than on trying to calculate the objective value of assets. A consequence of this, as noted by Allen, Morris and Shin (2006), is that in determining buying and selling prices, investors who are trying to predict future prices will rely excessively on the public information represented by the current market price because this is almost certainly a better source of information than any private information about the opinion of "the majority on average," a theoretical assertion supported by the empirical results of Study 1.

Though Studies 2 and 3 provide evidence that this belief is not wholly irrational because average opinion is indeed influential even when individuals are determining their own preferences, it is undoubtedly true that trying to forecast future prices is *not* the optimal strategy for maximizing average expected earnings in Study 4. In that setting, players who buy whenever the price is below objective (expected) value and sell whenever it is above will collectively make money from those following any other strategy, so such "value" strategy players will have the highest average earnings.

I estimate that across the nine completed markets of Study 4, the value strategy would hypothetically have resulted in average earnings of around $24, $5 more than overall average earnings and in the top quartile of payoffs. Nevertheless, I reviewed the trading patterns of all subjects in all markets in Study 4 and was unable to discover *any* who consistently used a value strategy, providing support for the assertion of Lei, Noussair, and Plott (2001) and Caginalp, Porter and Smith (2001) that even the most sophisticated players choose to use complementary strategies.

Why do they do so? One possibility is that the more sophisticated players are reliably able to be make enough money off the less sophisticated players to do even better than they would by using a value strategy. In Study 4, the nine subjects with the highest payoff in each market had an average payoff of $41.73, considerably more than the hypothetical value strategy would have garnered.

Unfortunately, the data from Study 4 do not allow us to definitively test whether these nine winners were indeed sophisticated players who skillfully took advantage of the unsophisticated players, or were simply lucky "noise" traders. After all, in order to play the momentum game successfully, players must be able to predict when the momentum-driven increase in price will reverse, which, as noted above, experimenters have not been able to do even after the fact. It is noteworthy, therefore, that the average number of shares held by the nine winners at the end of the game was 3.8. In other words, the most successful players held nearly twice the average number of shares held by all players at the end, whereas a fully rational player would hold fewer than average (and, ideally, zero). Since, as previously noted, in six of the nine markets, there was at least one player willing to pay more than the maximum value of the shares at the end of the game, we must wonder whether the holders of such large amounts of stock were efficiently maximizing their gains, or simply liked holding stock.

Study 4 also provides evidence that regardless of whether the winners in each market are behaving rationally, the mere awareness of their success increases the use of complementary strategies in the game. Thus, even though there are clear financial incentives to use a substitution (value) strategy, "performance pressure" can lead sophisticated players "to follow a poorly informed crowd, rather than betting against it" (Camerer and Fehr 2006, p. 51).

These four studies suggest that the initial impetus for the use of complementary strategies in experimental asset markets is a perception by subjects that the nature of the task is anticipating average opinion. If sufficiently widespread, this belief is not only self-fulfilling, but also self-propagating, because even individuals who initially construe the task in the way intended by experimenters will use complementary strategies if the importance of relative outcomes is made salient.

Before discussing the implications of this model for real-world financial markets, it is worth noting its implications for experimental economists. The standard assumption of experimental economists is that in a well-structured experiment, the experimenter is the sole source of "epistemic authority" (Kruglanski 2005), defining the "nature of the task" via the structure of the payoffs and the content of the instructions to the subjects. But one key theme in the psychological literature on group influence has been the role of the group in validating the nature of reality (Festinger 1954, Hardin and Higgins 1996), which raises the possibility that in a complex experimental environment involving multiple subjects, the group provides an alternative locus for epistemic authority.

The experimental markets that fail to collapse in Study 4 provide an example of how the epistemic authority of the group can be strong enough to cause some players to ignore or forget repeated instructions that the shares' value at the end of the game will be zero and instead accept the social norm represented by the market price as the correct price. Thus, even when prices do approximate expected value, it may not be because players have learned that expected value is the "right" price but because they have learned that *other* participants view it as the "right" price. In this sense, expected value emerges as the market price because it provides a natural focal point to coordinate the emergence of a social norm.

In short, though experimenters may believe that the "nature of the task" is to maximize average expected earnings, and a value strategy is the best way to do so, the evidence appears compelling that inexperienced subjects do not necessarily agree, but instead look to their fellow subjects to decide what is the collective judgment as to the "nature of the task."

<u>Drawing analogies between real-world and laboratory asset markets</u>

How, and how well, do financial markets work?

The answer to the second question depends critically on the answer to the first: market prices will be accurate if the actions of 'smart' traders and 'noise' traders are strategic substitutes, since in that case the 'smart' traders will correct the mistakes of the 'noise' traders. But market prices can be highly inaccurate if their actions are strategic complements, since in that case the 'smart' traders will accentuate the mistakes of the 'noise 'traders.

I have argued that whether substitution or complementarity dominates in real-world financial markets depends critically on whether investors perceive the nature of the task to be estimating the objective value of assets or "anticipating what average opinion expects the average opinion to be." Inexperienced subjects in experimental markets appear to construe the task as the latter, while experienced subjects appear to construe the task as the former. Which group is more representative of real-world investors?

EMH supporters argue that inexperienced experimental subjects are so unsophisticated that their behavior does not provide a useful analogy to that of real-world market participants. Indeed, there can be no doubt that many if not most inexperienced experimental subjects are thoroughly naïve: they clearly do not understand the significance of expected value in determining the correct price of shares, even when it is calculated for them. If experience results in efficient markets, it seems reasonable to assume that it is because subjects have learned the importance of this calculation, and thus have become more like real-world investors.

But this ignores two other critical differences between laboratory markets and real world ones. The first difference is that the asset in laboratory markets has a finite life.

Inexperienced laboratory subjects fail to take into account the fact that at the end of the game the shares will be worth zero, whereas experienced subjects seem to learn that this fact determines the correct price of the asset for all periods of the game via a process of backward induction. If, as argued by Camerer and Fehr (2006), the absence of a endpoint in real-world markets is a critical factor in encouraging the use of complementary strategies, inexperienced subjects who act as if the game will never end may be more representative of real-world investors, for whom the game does not in fact end.

Yet it appears to be the case that even subjects who are aware that the game will end also use complementary strategies, implying that the absence of an endpoint is not a necessary condition for their employment. Keynes' rationale for the use of complementary strategies emphasized instead another key difference between the laboratory and the real world: the laboratory asset has an objective value that can be easily calculated, while the basis of knowledge upon which the value of real-world assets must be estimated is "fluctuating, vague, and uncertain" and often without any "scientific basis on which to form any calculable probability whatever" (Keynes 1937, pp. 113-114).

Moreover, in comparison to the small stakes of the laboratory setting, where it seems reasonable to assume that most players will be risk-neutral, standard finance theory typically assumes some degree of risk aversion in the real world. Thus, even if an individual knew the stochastic distribution of future cash flows for a real world asset with certainty, the "objective" current value of the asset will also depend on the individual's subjective attitude toward risk (or variance of outcomes). Finance theory assumes that, though subjective, one's risk attitude is a purely personal preference which is determined independently of the risk attitudes of others, so that an individual who knows the distribution of possible future cash flows of an asset can at least calculate what the asset is worth to himself. Studies 2 and 3 provide evidence that this assumption is questionable because risk preferences are in part socially determined.

Thus, the assertion that financial assets actually have a single, objective value even to a particular, fully-informed individual is open to question. This uncertainty is what led Keynes to suggest that predicting the future behavior of the crowd is actually easier than estimating objective value, and to propose a very different view of what market prices represent: "Knowing that our own individual judgment is worthless, we endeavour to fall back on the judgment of the rest of the world which is perhaps better informed. That is, we endeavour to conform with the behavior of the majority on average. The psychology of a society of individuals each of whom is endeavouring to copy the others leads to what we may strictly term a conventional judgment" (Keynes 1937, p. 114).

I argue that Keynes' description offers a reasonable explanation for the results of Study 4. Inexperienced subjects question the importance of their own individual judgment and thus initially value the asset at even less than they would if there was no resale market, because they are waiting to see "the judgment of the rest of the world." The subsequent rise in price, presumably due at first to value investors taking advantage of the undervaluation, leads others to "endeavour to conform with the behavior of the majority," i.e., to match the strategy used by other players. When subjects construe the observed increase in price as resulting from others' use of a value strategy, strategy matching results in price approximating expected value. More often, however, they interpret it as resulting from momentum beliefs, and strategy matching then results in a bubble. Given the right circumstances, this process can even result in subjects' adopting a conventional judgment about the correct price of the asset that ignores the instructions provided by the experimenter.

Keynes' focus on the importance of uncertainty in encouraging strategy matching is consistent with a long line of research in social psychology indicating that individuals rely more heavily on the judgments of others in ambiguous or uncertain situations (Sherif 1935, Asch 1952, Deutsch & Gerard 1955). Of particular relevance is research showing that reliance on others for difficult judgment tasks is even greater when the task is particularly important (Baron, Vandello and Brunsman 1996), as clearly would be the case in real-world capital markets.

Obviously, imitating the actions of others can be perfectly rational, though a line of research on "information cascades" has demonstrated that excessive imitation can interfere with the logic that makes it rational in the first place (Bikhchandani, Hirshleifer and Welch 1998). Keynes' argument, however, went beyond purely rational aspects of imitative behavior to acknowledge that these are only one facet of a broader set of social motivations for conformity (see Prislin and Wood 2005 for a review). He noted that "it is the long-term investor [who predicts future cash flows] who will in practice come in for most criticism, wherever investment funds are managed by committees or boards or banks. For it is the essence of his behaviour that he should be eccentric, unconventional and rash in the eyes of average opinion" (Keynes 1936, p. 157).

After all, the substitution strategy pursued by such an investor by definition means doing the opposite of average opinion, i.e., going against the social norm, which research has demonstrated leads to social disapproval (Schachter 1951).

Finally, as noted by a Goldman, Sachs financial institutions analyst, "the real business of [professional] money management is not managing money, it is getting money to manage" (Basak, Pavlova, and Shapiro 2007). If a manipulation as subtle as simply drawing attention to the performance of the market leader increases the likelihood of laboratory bubbles, it seems highly plausible that the much higher stakes of relative performance for professional investors would have a similar effect. Here, too, Keynes argued that uncertainty magnified the incentives to pursue complementary strategies, since investment committees face the same difficulty as experimenters in trying to distinguish luck from skill. In one of his most quoted passages, he argued that "[w]ordly wisdom teaches that it is better for reputation to fail conventionally than to succeed unconventionally" (Keynes 1936, pp 157-58).

Conclusion

In a review of the extensive economics literature on the impact of imitation and herd behavior, both rational and non-rational, on capital markets, Hirshleifer and Teoh (2003) note that research assuming imperfect rationality has been handicapped because "behavioural assumptions… are usually not based upon experiments that are very close to the particular economic setting being modeled" (p. 38). The research reported here has attempted to address that concern by demonstrating that the process that people use in assigning prices to risky assets in markets is fundamentally different from the one they use in assigning prices to risky assets for their own purposes.

The key theme is that complementary strategies are likelier to be used when the object of judgment is collective judgment itself rather than an objective value, and that this is itself likelier to happen the more difficult it is to determine objective value. Furthermore, the decision as to which type of judgment is relevant is itself socially influenced, because the widespread use of complementary strategies is self-reinforcing in general, and particularly so when agents are concerned with relative outcomes.

Thus, given the enormous uncertainty of the correct value of the infinitely lived assets in capital markets; the importance of relative outcomes generally, but especially for professional investors; and the powerful social motivations to conform, I argue that inexperienced subjects who do not comprehend the significance of the expected value, and whose attention is drawn to relative outcomes, are reasonably representative of real-world investors.

As for the accuracy of prediction markets, while it is almost certainly the case that their finite nature is a key factor enabling substitution players to dominate, the research reported here suggests that their accuracy may also be due to the fact that marginal traders in these markets are not focused on relative outcomes. Given the evidence supporting the importance of relative motivations in general, this implies the paradoxical possibility that prediction markets work well precisely because they are small and economically insignificant. This possibility is supported by evidence that they can work equally well if there is no actual money at stake (Servan-Schreiber, Wolfers, Pennock and Galebach 2004).

As a final note, Keynes (1936) observed that while conventional judgments may show a remarkable degree of stability, they are "liable to change violently as the result of a sudden fluctuation of opinion" (p. 152). Keynes' view, unlike EMH, offers an explanation for the many sudden and severe fluctuations in financial markets that seem unrelated to any obvious external factors, such as the October 1987 market crash. Given Einstein's famous dictum that theories should be as simple as possible, but no simpler, I suggest that the Keynesian approach offers a more complex, but also more accurate, model for a ubiquitous and important feature of the modern global economy.

References

Allen, Franklin, Stephen Morris and Hyun Song Shin (2006). Beauty Contests, Bubbles and Iterated Expectations in Asset Markets. Wharton Financial Institutions Center working paper.

Asch, Solomon (1952). *Social Psychology*. New York: Prentice Hall.

Barber, Brad M., Terrance Odean and Ning Zhu (2006). Do Noise Traders Move Markets? EFA 2006 Zurich Meetings Working Paper.

Baron, Robert S., Joseph A. Vandello and Bethany Brunsman (1996). The Forgotten Variable in Conformity Research: Impact of Task Importance on Social Influence. *Journal of Personality and Social Psychology, 71* (5), 915-927.

Barsade, Sigal G. (2002). The Ripple Effect: Emotional Contagion in Groups. *Administrative Science Quarterly, 47* (4), 644-675.

Basak, Suleyman, Anna Pavlova, and Alex Shapiro (2007). Offsetting the Incentives: Risk Shifting and Benefits of Benchmarking in Money Management. *Review of Financial Studies*, in press.

Becker, G. M., M.H. DeGroot, and J. Marschak (1964). Measuring utility by a single-response sequential method. *Behavioral Science, 9*, 226-23.

Benartzi, Shlomo, & Thaler, Richard H. (1999). Risk Aversion or Myopia? Choices in Repeated Gambles and Retirement Investments. *Management Science, 45*(3), 364-81.

Berg, Joyce E. and Thomas A. Reitz (2006). The Iowa Electronic Markets: Stylized Facts and Open Issues. In Robert W. Hahn and Paul C. Tetlock (Eds), *Information Markets: A New Way of Making Decisions.* Washington, DC: AEI-Brookings Joint Center for Regulatory Studies.

Bikhchandani, Sushil, Hirshleifer, David, and Welch, Ivo (1998), Learning from the Behavior of Others: Conformity, Fads, and Informational Cascades. *Journal of Economic Perspectives, 12* (3), 151-170.

Caginalp, G., D. Porter, and V. Smith, (2001), Financial bubbles: Excess cash, momentum, and incomplete information. *The Journal of Psychology and Financial Markets, 2*(2), 80-99.

Camerer, Colin and Ernst Fehr (2006). When Does "Economic Man" Dominate Social Behavior? *Science, 311*, 47-52.

Camerer, Colin and M.W. Weber (1992). Recent developments in modeling preferences: uncertainty and ambiguity. *Journal of Risk and Uncertainty, 5*, 325-370.

Cass, David and Karl Shell (1983). Do Sunspots Matter? *Journal of Political Economy, 91*, 193-227.

Clark, Andrew E. and Andrew J. Oswald (1998). Comparison-concave utility and following behaviour in social and economic settings. *Journal of Public Economics, 70*, 133-155.

Cooper, Russell W. (1999). *Coordination Games: Complementarities and Macroeconomics*. Cambridge: Cambridge University Press.

De Long, J. Bradford, Andrei Shleifer, Lawrence H. Summers, and Robert J. Waldmann (1990). Noise Trader Risk in Financial Markets. *Journal of Political Economy, 98* (4), 703-738.

DeMarzo, Peter M., Ron Kaniel, and Ilan Kremer (2005). Relative Wealth Concerns and Financial Bubbles. Working Paper.

Deutsch, M. and H. B. Gerard (1955). A study of normative and informational social influences upon individual judgment. *Journal of Abnormal and Social Psychology, 51,* 629-636.

Diener, Ed, and R. Biswas-Diener (2002). Will money increase subjective well-being? A literature review and guide to needed research. *Social Indicators Research, 57*, 119-16.

Dufwenberg, Martin, Tobias Lindqvist, and Evan Moore (2005). Bubbles and Experience: An Experiment. *The American Economic Review, 95* (5), 1731-1737.

Fehr, Ernst and Jean-Robert Tyran (2005). Individual Irrationality and Aggregate Outcomes. *Journal of Economic Perspectives, 19* (4), 43-66.

Festinger, Leon (1954). A theory of social comparison processes. *Human Relations, 5,* 327-346.

Firebaugh, Glenn and Laura Tach (2005). Relative Income and Happiness: Are Americans on a Hedonic Treadmill? Pennsylvania State University Working Paper.

Fischbacher, Urs (2007), z-Tree: Zurich Toolbox for Ready-made Economic Experiments, *Experimental Economics, 10* (2), 171-178.

Frank, Robert H. (1985). *Choosing the Right Pond.* New York: Oxford University Press.

Frank, Robert H. and Cass Sunstein (2001). Cost-Benefit Analysis and Relative Position. *The University of Chicago Law Review, 68* (2), 323-374.

Hardin, C.D. and E. Tory Higgins (1996). Shared reality: How social verification makes the subjective objective. In R. M. Sorrentino and E. T. Higgins (Eds), *Handbook of Motivation and Cognition (Vol. 3).* New York: The Guilford Press.

Haruvy, Ernan and Charles Noussair (2006). The Effect of Short Selling on Bubbles and Crashes in Experimental Spot Asset Markets. *Journal of Finance, 61* (3), 1119-1157.

Hirshleifer, David and Siew Hong Teoh (2003). Herd Behavior and Cascading Capital Markets: a Review and Synthesis. *European Financial Management, 9* (1), 25-66.

Hunter, William C., George G. Kaufman, and Michael Pomerleano (2003). *Asset Price Bubbles: The Implications for Monetary, Regulatory, and International Policies.* Cambridge: The MIT Press.

Isaac, R. Mark and Duncan James (2003). Boundaries of the Tournament Pricing Effect in Asset Markets: Evidence from Experimental Markets. *Southern Economic Journal, 69* (4), 936-951.

Kahenman, Daniel, Jack L. Knetsch, and Richard Thaler (1991). The Endowment Effect, Loss Aversion, and Status Quo Bias. *Journal of Economic Perspectives, 5* (1), 193-206.

Keynes, John Maynard (1936/1997). *The general theory of employment, interest, and money*. Amherst: Prometheus Books.

Keynes, John Maynard (1937/1973). In Donald Moggridge (Ed.), *The Collected Writings of John Maynard Keynes (Vol. XIV)*. London: Macmillan.

Krantz, David H. and Howard C. Kunreuther (2006). Goals and Plans in Protective Decision Making. NBER Working Paper 12446.

Kruglanski, Arie (2005). Says Who?: Epistemic Authority Effects in Social Judgment. In M.P. Zanna (Ed), *Advances in Experimental Social Psychology (Vol 37).* New York: Academic Press.

Lei, Vivian, Charles N. Noussair, and Charles R. Plott (2001). Nonspeculative Bubbles in Experimental Asset Markets: Lack of Common Knowledge of Rationality vs. Actual Irrationality. *Econometrica, 69* (4), 831-859.

Loewenstein, George F., Elke U. Weber, Christopher K. Hsee, and Ned Welch (2001). Risk as Feelings. *Psychological Bulletin, 127* (2), 267-286.

Luttmer, Erzo (2005). Neighbors as Negatives: Relative Earnings and Well-Being. *Quarterly Journal of Economics, 120* (3), 963-1002.

Meltzer, Allan H. (2003). Rational and Nonrational Bubbles. In William C. Hunter, George G. Kaufman, and Michael Pomerleano (Eds), *Asset Price Bubbles: The Implications for Monetary, Regulatory, and International Policies.* Cambridge: The MIT Press.

Morris, Michael W., Oliver J. Sheldon, Daniel R. Ames and Maia J. Young (2007). Metaphors and the Market: Consequences and preconditions of agent and object metaphors in stock market commentary. *Organizational Behavior and Human Decision Processes, 102*, 174-192.

Neumark, David and Andrew Postlewaite (1998). Relative income concerns and the rise in married women's employment. *Journal of Public Economics, 70*, 133-155.

Pastor, L. and P. Veronesi (2007). Was There a Nasdaq Bubble in the Late 1990s? *Journal of Financial Economics*, forthcoming.

Plott, Charles R. and Peter Gray (1990). The Multiple Unit Double Auction. *Journal of Economic Behavior and Organization, 13* (2), 245-258.

Porter, D.P, and V.L. Smith (2003). Stock market bubbles in the laboratory. *Journal of Behavioral Finance, 4* (1), 7-20.

Prislin, R., & Wood, W. (2005). Social influence: The role of consensus in attitudes and attitude change. In D. Albarracín, B. T. Johnson, & M. P. Zanna (Eds.), *The Handbook of Attitudes and Attitude Change*. Mahwah, NJ: Lawrence Erlbaum Associates.

Schachter, Stanley (1951). Deviation, rejection and communication. *Journal of Abnormal and Social Psychology, 46*, 190-207.

Schelling , Thomas (1960). *The Strategy of Conflict*. Cambridge: Harvard University Press.

Schoenberg, Eric J. (2004). Reference Outcome Determination in a Financial Market Setting: A New Experimental Methodology. Columbia University working paper.

Servan-Schreiber, Emile, Justin Wolfers, David Pennock and Brian Galebach (2004). Prediction Markets: Does Money Matter? *Electronic Markets, 14* (3), 243-51.

Shleifer, Andrei & Vishny, Robert W (1997). The Limits of Arbitrage. *Journal of Finance, 52* (1), 35-55,

Sherif, M. (1935). A study of some social factors in perception. *Archives of Psychology, 27* (187).

Smith, V., G. Suchanek, and A. Williams (1988). Bubbles, crashes, and endogenous expectations in experimental spot asset markets. *Econometrica, 56*, 1119-1151.

Solnick, Sara J. and David Hemenway (1998). Is more always better?: A survey on positional concerns. *Journal of Economic Behavior & Organization, 37*, 373-383.

Taylor, S.E., & Lobel, M. (1989). Social comparison activity under threat: Downward evaluation and upward contacts. *Psychological Review, 96*, 569-575.

Weber, Elke U. and Christopher K. Hsee, C. K. (1998). Cross-cultural differences in risk perception but cross-cultural similarities in attitudes towards risk. *Management Science, 44*, 1205-1217.

Weber, Elke U. and R. Milliman (1997). Perceived risk attitudes: Relating risk perception to risky choice. *Management Science, 43*, 122-44.

Weber, E. U., Siebenmorgen, N., Weber, M. (2005). Communicating asset risk: How name recognition and the format of historic volatility information affect risk perception and investment decisions. *Risk Analysis, 25*, 597-609.

Wolfers, Justin and Eric Zitzewitz (2005). Prediction Markets in Theory and Practice. In L. Blume and S. Durlauf (Eds.), *New Palgrave Dictionary of Economics,* 2nd edition, forthcoming.

Wooten, David B. and Americus Reed II (1998). Informational Influence and the Ambiguity of Product Experience: Order Effects on the Weighting of Evidence. *Journal of Consumer Psychology, 7* (1), 79-99.

Yaniv, Ilan (2004). Receiving other people's advice: Influence and benefit. *Organizational Behavior and Human Decision Processes, 93*, 1-13.

Appendix A

Dice Game Instructions

Willingness to Accept

The ticket you have just been given entitles you to roll of a pair of dice *once*. You will win one of the following amounts of money:

If the two dice total:	You win:	Frequency of this outcome:
2 or 12	$30	2 in 36
3 or 11	$5	4 in 36
4, 5, 9 or 10	$2	14 in 36
6, 7 or 8	0	16 in 36

Note that if you were to play this game many times, you would expect on average to receive $3 each time you played.

Before you play this game, we will give you a chance to sell your ticket back to us instead of playing. We will place in a bag seven slips of paper with the following values written on them: $0.50, $1.00, $1.50, $2.00, $2.50, $3.00, and $3.50. We will draw *one* slip of paper from the bag and offer to buy your ticket for the value written on that slip.

For example, if we draw the slip that says $2.50, we will offer to buy the ticket for $2.50.

- If you have told us you would be willing to accept $2.50 for the ticket you own, we will give you $2.50 and you will *not* play the game.
- If you told us you would *not* be willing to accept $2.50 for the ticket you own, you will play the game and receive the amount determined by the roll of the dice.

You must decide **in advance of the draw** whether you would prefer to keep the ticket or to sell the ticket for the amount that is drawn. Please circle your choices on the list below:

If we offer to buy your ticket for $0.50, will you sell it? Y N
If we offer to buy your ticket for $1.00, will you sell it? Y N
If we offer to buy your ticket for $1.50, will you sell it? Y N
If we offer to buy your ticket for $2.00, will you sell it? Y N
If we offer to buy your ticket for $2.50, will you sell it? Y N
If we offer to buy your ticket for $3.00, will you sell it? Y N
If we offer to buy your ticket for $3.50, will you sell it? Y N

ONLY if you answered "<u>no</u>" to all of the above questions, please fill in the blank below with the *minimum* amount of money you would need to receive in order to sell your ticket.

I would sell my ticket if I received *at least* $_____.

Appendix B
Penny Jar Game Instructions

Everyone who participates in this experiment will have two chances to win additional money (we expect approximately 100 participants in total).

In Contest 1, the winner will be the person who guesses closest to the **actual number of pennies in Jar A**. If two guesses are equally close, the winner will be the person with the higher guess.

Your initial guess was _____ and the average guess of the people in *this* group was _____

How many pennies do you estimate are in Jar A? _____

In Contest 2, the winner will be the person who guesses closest to the **average of all participants' guesses of the number of pennies in Jar B**. If two guesses are equally close, the winner will be the person with the higher guess.

Your initial guess was _____ and the average guess of the people in *this* group was _____

How many pennies do you estimate are in Jar B? _____

The prize for one contest will be $10 and for the other $5. You get to choose which of the two contests offers the larger prize. Please circle one of the following two options:

I would like to receive the $10 prize if I win Contest 1 and the $5 prize if I win Contest 2

I would like to receive the $10 prize if I win Contest 2 and the $5 prize if I win Contest 1

Appendix C

Stock Market Game Instructions (as revised after Market 4)

This is an experiment in the economics of market decision making. The experiment will consist of a sequence of 15 trading periods in which you will have the opportunity to buy and sell in a market. Your payment at the end of the experiment will be equal to $5 PLUS whatever you earn during the course of the experiment. The average payment is $18.05, but your actual payment could be higher or lower.

You will each begin with a combination of cash and shares. Cash in the experiment is shown in cents. Shares are assets which pay a dividend at the end of each of 15 periods. The amount of the dividend is one of the four following values, each of which is equally likely: 0 cents, 8 cents, 28 cents, or 60 cents. The average dividend in each period is 24 cents. At the end of each of the 15 trading periods, the computer will randomly select one of those four values, and you will receive dividends for each share in your inventory. The dividend is added to your cash balance automatically. Your cash balance and your inventory of shares carries over from one trading period to the next. After the dividend is paid at the end of period 15, there will be no further earnings possible from shares. **In other words, at the end of the experiment, the shares are worth nothing.**

We will now explain how you will use your computer to buy and sell shares, and to keep track of your account through the course of the experiment. There will be 15 trading periods, each of which last for 3 minutes, or 180 seconds. The time remaining in the period is shown in the upper right corner of your screen.

At the beginning of the experiment, everyone receives a combination of shares of an asset plus cash. On the left-most column of your computer screen, in the top left corner, you can see the Money you have available to buy Shares and in the middle of the column, you see the number of Shares you currently have.

The shares can be bought and sold in a computerized market. If you would like to offer to SELL a share, use the text area entitled "Enter ask price" in the second column. In that text area you can enter the price at which you are offering to sell a share, and then select "Submit Ask Price". Please do so now.

You will notice that nine numbers, one submitted by each participant, now appear in the third column from the left, entitled "Ask Price". The lowest ask price will always be on the bottom of that list and will be highlighted. If you press "Buy", the button at the bottom of this column, you will buy one share for the lowest current ask price. You can also highlight one of the other prices if you wish to buy at a price other than the lowest.

Please purchase a share now by highlighting a price and selecting "Buy". Since each of you had put a share for sale and attempted to buy a share, if all were successful, you all have the same number of shares you started out with. This is because you bought one share and sold one share.

When you buy a share, your Money decreases by the price of the purchase. When you sell a share your Money increases by the price of the sale.
You may also make an offer to BUY a share by entering a number in the text area entitled “Enter bid price.” Then press the red button labeled “Submit Bid Price”. You can sell to the person who submitted an offer if you highlight the offer, and select “Sell”. Please do so now for one of the offers.

Please note that you if you attempt to “Buy” a share listed in the “Ask” table, you must have enough money to buy the share at the offered price, and if you attempt to “Sell” for an amount listed in the “Bid” table, you must have a share to sell. If you do not have enough money, or enough shares, you will get an error message. You will also get an error message if you attempt to buy or sell a share from yourself. *Please be aware that once you post a bid or an ask, you CANNOT change it, so make sure you do not enter the wrong price in error.*

At the end of each trading period, you will have an opportunity to buy a single ticket for a lottery. The ticket costs 6 cents and offers a 5% chance (i.e. 1 in 20) of winning 120 cents. If you choose to buy a ticket, 6 cents will be subtracted from your account, and, if the winning number is drawn, everyone who has a bought a ticket will win 120 cents. Please choose “yes” for this practice round.

After everyone has decided whether or not to buy a lottery ticket, you will receive a status report for the period just ended. The status report includes the following information:

- Your cash account at the end of the prior period
- The dividend payment for this period
- The number of shares you currently own
- The total amount of dividends you receive (that is, the number of shares you own multiplied by the dividend payment for the period).

- The cost of the lottery ticket, if you bought one.
- The payoff of the lottery ticket.

- And finally, you will see your cash account at the end of this period
- The number of shares that you currently own
- The current price of the shares (defined as the best bid in the preceding period, since this represents what you could have sold the share for)
- Your account total (that is, your cash account plus the value of your shares)

In addition, you will also see how much the person with largest[smallest] account has.

Finally, you will be asked a question about how you feel about your current account level. Once everyone has answered that question, the next round of the game will begin. Please wait until I finish the instructions before entering a value.

The *only* earnings you will receive for the experiment will be $5 you receive for participating plus the amount of *cash* that you have at the end of period 15, after the last dividend has been paid. The amount of cash you will have is equal to:

The cash (called "money" on your screen) you have at the beginning of the experiment

+ dividends you receive (when you have more than zero shares)

+ money received from sales of shares

- money spent on purchases of shares

We have provided a sheet of paper to help you make decisions. First, it includes a basic reminder that if you want to sell a share for a particular amount, you enter an ask price, and if you want to buy a share for a particular amount, you enter a bid price.

Second, we provide an AVERAGE HOLDING VALUE TABLE. There are 4 columns in the table. The first column, labeled Current Period, indicates the period during which the average holding value is being calculated. The second column gives the number of holding periods from the period in the first column until the end of the experiment. The third column, labeled Average Dividend per Period, shows the average amount of the dividend. Since the dividend on a Share has a 25% chance of being 0, a 25% chance of being 8, a 25% chance of being 28 and a 25% chance of being 60 in any period, the dividend is on average 24 per period for each Share. The fourth column, labeled Average Holding Value Per Share, gives the average value for each share from the current period until the end of the experiment.

Suppose for example that there are 7 periods remaining. If you hold a Share for 7 periods, the total dividend for the Share over the 7 periods is on average 7*24 = 168. Therefore, the total value of holding a Share over the 7 periods is on average 168.

You will now have a practice period. Your actions in the practice period do not count toward your earnings and do not influence your position later in the experiment. The goal of the practice period is only to master the use of the interface. Please be sure that you have successfully submitted bid prices and ask prices. Also be sure that you have accepted both bid and ask prices. You are free to ask questions, by raising your hand, during the practice period. Once everyone has entered a rating, the practice period will begin.

Appendix D

STOCK MARKET GAME EXPERIMENT HELP SHEET

"Enter Ask Price" =
I want to sell a share for $X

"Enter Bid Price" =
I want to buy a share for $Y

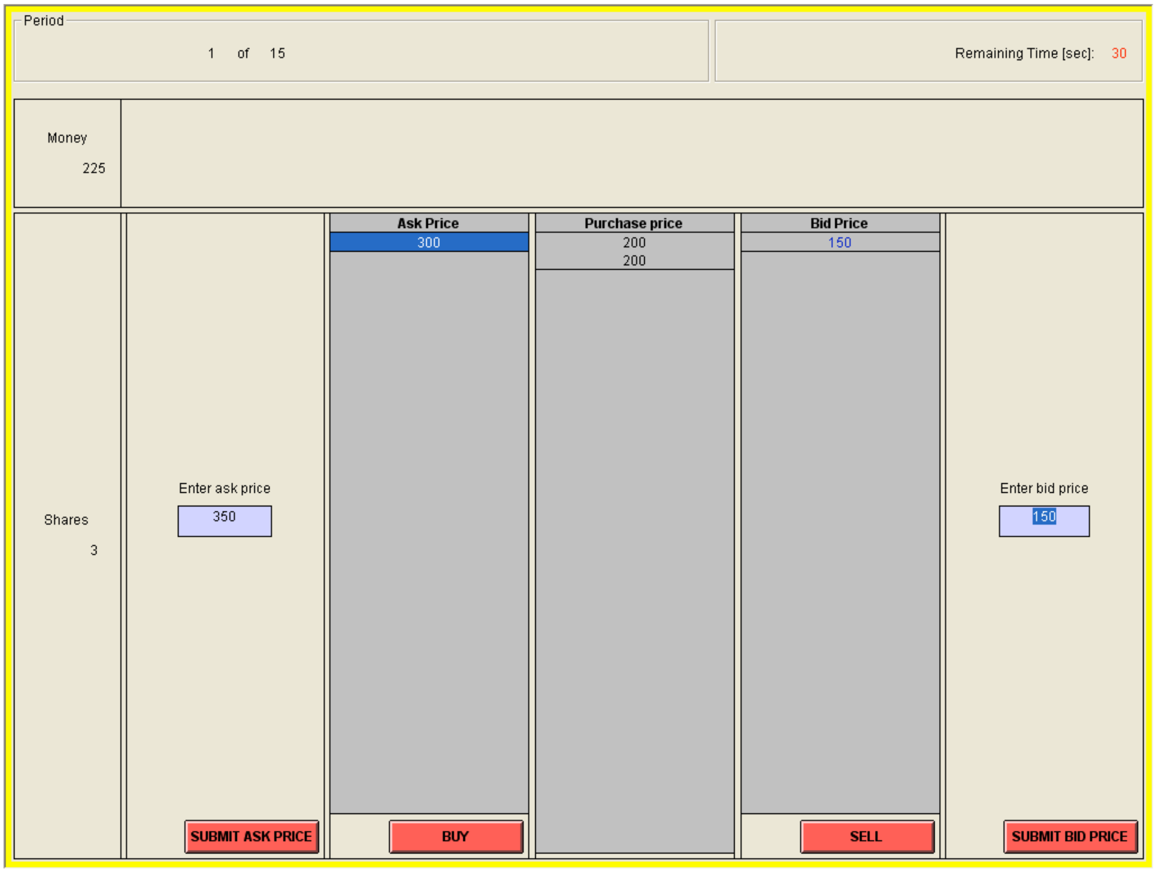
BUY = I will buy a share
for the price highlighted above

SELL = I will sell a share
for the price highlighted above

AVERAGE HOLDING VALUE TABLE

Current Period	Number of Periods Remaining	x	Average Dividend Per Period	=	Average Holding Value Per Share
1	15		24		360
2	14		24		336
3	13		24		312
4	12		24		288
5	11		24		264
6	10		24		240
7	9		24		216
8	8		24		192
9	7		24		168
10	6		24		144
11	5		24		120
12	4		24		96
13	3		24		72
14	2		24		48
15	1		24		24

Appendix E
STOCK MARKET GAME TRADING SCREEN



Appendix F

STOCK MARKET GAME STATUS REPORT SCREEN