THE ROLE OF THE INTERACTION BETWEEN INFORMATION AND BEHAVIORAL BIAS IN EXPLAINING HERDING[**]

Beatriz Fernández (beatriz@emp.uva.es)
Teresa Garcia-Merino (temerino@eco.uva.es)
Rosa Mayoral (rmayoral@eco.uva.es)
Valle Santos (mvalle@eco.uva.es)
Eleuterio Vallelado (teyo@eco.uva.es) [*]
University of Valladolid
Valladolid, Spain

ABSTRACT:

The current research aims to analyze the interaction between the uncertainty of the financial environment and individuals' cognitive profile to explain investors' herding behavior. The authors design and conduct an experiment to observe the behavior of subjects in three settings, each with a different level of information. The results confirm that a dependence relation exists between feeling of uncertainty, investors' behavioral biases and the herding phenomenon. Moreover, the experiment shows that the determinants of herding—information and behavioral biases—are not mutually independent. Specifically, the presence of high levels of uncertainty favors herding behaviors regardless of inter-individual differences, and only when the level of uncertainty is low are the biases in the individual behavior capable of explaining investors' herding behavior.

Keywords: Uncertainty, herding, individual behavior, laboratory experiment.
JEL: G14, C91, D8

[**] The authors are from the Departments of Financial Economics and Accounting, and Management, University of Valladolid. They have benefit from the useful comments of S. Glucksberg, D. Hillier and J. A. Rodríguez, as well as participants at the XVIII ACEDE Conference. Financial support from Consejería de Economía y Empleo (Junta de Castilla y León) is also acknowledged. Any errors are the responsibility of the authors
[*] Corresponding author: Eleuterio Vallelado**,** Universidad de Valladolid, Departamento de Economía Financiera y Contabilidad, Avda. Valle de Esgueva, 6, 47011 Valladolid, Spain. Phone: +34 983423387, Fax: +34 983183830, e-mail: teyo@eco.uva.es

THE ROLE OF THE INTERACTION BETWEEN INFORMATION AND BEHAVIORAL BIAS IN EXPLAINING HERDING

1. INTRODUCTION

The efficient market hypothesis holds that information is equally accessible to all investors and these investors interpret the information in an unequivocally rational way. Consequently, asset prices incorporate all the existing information at all moments in time because errors are independent across individuals such that they cancel out in equilibrium. On the other hand, investors cannot possibly digest the huge quantity of information present in markets. If as a consequence of uncertainty or ability limitations people share heuristics then individuals have the same biases which imply that errors are not independent across them (Hirshleifer, 2001). Thus, the rational approach in finance is subsumed by a broader approach, behavioral finance, where expected returns are determined by risk and misevaluation (Hirshleifer, 2001). DeBondt *et al.* (2008) summarizes the findings in behavioral finance in three classes: a) There is a catalog of biases; b) Investor sentiment matters and c) Decision processes shape decision outcomes. As a result they identify three building blocks: sentiment, behavioral preferences and limits to arbitrage. In the more general approach, the experiments in laboratory, the financial behavior and market results appear to be connected.

Investors sometimes opt for imitation to cope with the informational limitations in the markets. When many of such investors imitate at the same time herding appears. Devenow and Welch (1996) argue that herding imply behavior patterns that are correlated across individuals. It requires a coordination mechanism that can be either a signal or an ability to observe other decision makers. Such behavior becomes relevant when the volatility induced by herding increases the fragility of financial markets and destabilizes the broader market system (Bikhchandani and Sharma, 2001, Chari and Kehoe, 2004).

The main consensus is that herding can be construed as being either rational (Barnerjee, 1992; Bikhchandani *et al.*, 1992; Welch, 1992) or irrational (Keynes, 1936, Hirshleifer, 2001) form of investor behavior. Devenow and Welch, (1996) define the rational view of herding as the one centered on externalities. Thus, optimal decision making is distorted by information difficulties or incentive issues. The non rational view of herding centers on investor psychology. Agents behave following one another blindly

and foregoing rational analysis. Finally, the intermediate view holds that decision makers are near rational, economizing on information processing or information acquisition costs by using heuristics.

Our approach in this work is to consider investors' psychology about the reliability of their information as the element that precipitates herding. Research on rational herding has traditionally focused on asymmetric information[1] but according to Allen *et al.* (1993) common knowledge of actions negates asymmetric information in the sense that agents would have behaved in the same way without the private part of their information. On the other hand, the literature also recognizes that investors' sensation that other investors are better informed than they are is decisive in encouraging them to ignore their private information and to imitate other investors' decisions. Investors who imitate do not know the quality of other investors' information, financial market trends thus being based on the mood of investors and not on rational responses (Parker and Prechter, 2005). Therefore, the investors' cognitive profile becomes an important explanatory factor of the herding phenomenon.

A large number of analyses of this behavior focus on the question of whether, in function of the available information, herding is evident in the market or not. Many studies of the origin of this phenomenon focus on the behavior of fund managers and analysts. In this case, authors focus on rational herding considering compensation systems and concern for reputation to be responsible for the presence of herding (Scharfstein and Stein, 1990; Zeckhauser *et al.*, 1991; Bikhchandani and Sharma, 2001). But few researchers have tried to explain the origin of herding by looking at human nature (Graham, 1999; Cipriani and Guarino, 2005 and 2007; Bernardo and Welch, 2001). The current research classifies in the last group. It aims to look in more depth at the non rational factors inducing herding behavior in the capital markets, and analyze whether investors' individual profiles determine their herding behaviors. Specifically, the research hinges around a central proposition that postulates the existence of an interaction between uncertainty (lack of information) and investors' cognitive profile, and that this interaction has an effect on herding.

Studying this phenomenon is complex because the researcher must identify how investors treat different types of information, and also discriminate between "true or

[1] See Bikhchandani and Sharma (2001) survey of herd as rational investor behavior. According to these authors rational herd is related to imperfect information, concerns for reputation and compensation structures.

intentional herding" and the so-called "spurious herding". Intentional herding occurs when a group of investors consciously copies the decisions of other investors; spurious herding occurs when decision-makers are faced with similar information and problems and take the same decisions without necessarily observing each other (Bikhchandani and Sharma, 2001). The method used in this research includes an experiment to study this question empirically. This technique is appropriate, because it allows the researcher to observe individuals' behavior in a controlled way.

The results of the experiment show that uncertainty is more important than the individual cognitive profile in explaining herding among investors. However, as the level of uncertainty diminishes, the investors' cognitive profile can explain why individuals show different imitation propensities in identical informational contexts.

This paper is organized as follows. After this introduction, Section 2 reviews the determinants of herding. Specifically, it presents the hypotheses about the influence of uncertainty and investors' cognitive profile on investors' decision making. Section 3 then describes the design of the empirical analysis and the laboratory experiment carried out. The fourth section looks at the results of the analysis. Finally, Section 5 discusses the main conclusions of the work and its implications for future research.

2. INFORMATION, BEHAVIORAL BIAS AND HERDING

Rational investors combine different sources of information using Bayes rule: the weights placed on the different pieces of information should be proportional to their respective precision (Daniel and Titman, 1999). The classic approach in finance is that only outcomes matter. Following this approach, behavioral biases cancel out in the aggregate because either they are averaged out or they are corrected for by rational arbitrage. Barberis and Thaler (2003) argue that arbitrage cannot eliminate all effects of behavioral biases in financial markets due to: fundamental risk, noise trader risk, or implementation costs. Even if we accept the classic approach it would be still valuable to discriminate between individuals that are less and more affected by behavioral biases (Oechssler *et al*, 2008) because market behavior may at times be extreme and seemingly irrational.

Investors cannot possibly digest the huge quantity of information present in markets (Simon, 1957). Besides, people are likely to bias in valuing securities for which information is sparse (Hirshleifer and Luo, 2001). They are often not aware of all the

information signals, and are often unable to analyze all the information they receive (Wärneryd, 2001). Individuals have limited processing ability and hence use vague *ad hoc* rules to translate the information they receive into estimates of cash flows and company valuations. Then, investors must do much of their analysis based on hunches or feelings which can easily be influenced by behavioral biases. (Daniel and Titman, 1999).

Devenow and Welch, (1996) indicate that independent decision making across market participants is a fiction. Many influential market participants emphasize that their decisions are highly influenced by other market participants. The behavior of an investor to imitate the observed actions of others or the movements of market, instead of following their own beliefs and information, is usually termed as herding (Wang, 2008). Herding is among the most mentioned but least understood terms in the financial lexicon.

Herding in the capital markets can be defined as the tendency of a group of investors to buy (sell) certain stocks at the same time, compared to what would be expected if the investors were working independently (Lakonishok *et al.*, 1992). A group of investors adopts the same decisions as other investors, ignoring their own information (Bikhchandani *et al.*, 1992; Avery and Zemsky, 1998), even if they are not sure that other investors have made the right decision (Banerjee, 1992).

2.1 Information uncertainty and herding

Investors' decisions are surrounded by uncertainty, not only because of the informational limitations in the markets themselves but also because of individuals' cognitive limitations. There is uncertainty not only about the real value of the securities being traded but also about the quality of the information available. In uncertain contexts, investors tend to think that other investors are better informed and have important information that they lack. Thus, the investors try to deduce what information the other investors have by observing their decisions.

If an individual has access to public and private information and they are of equal value in predicting the asset's intrinsic value the individual would put equal weight on private and public signals. When the individual knows that others have also observed the same public signal, the public signal is a better predictor of average opinion. He will put more weight on the public signal than on the private signal. If individuals' willingness to pay

for an asset is related to their expectations of average opinion, then we will have asset prices overweighting public information relative to the private information (Allen *et al*, 2006). A number of authors have noted that agents will not act on private information if they do not expect private information to be reflected in asset prices at the time they sell the asset (Froot *et al.*, 1992). Besides, there is no guarantee that financial decisions problems will be presented to individuals in a manner that favors the most accurate decisions (Hirshleifer, 2001).

In short, information available to investors is linked to the degree of uncertainty they perceive and how the information is presented. Then, the first hypothesis is:

H_1: Herding behavior is more frequent in high-uncertainty contexts

2.2 Uncertainty, investors' cognitive profile and herding

Human heterogeneity and idiosyncrasy play a role in the development of major financial events. Researchers have been identifying systematic patterns in financial markets. Those patterns are financial anomalies or biases. The rational economic paradigm (the way the world should be) and the behavioral tendencies (the way the world is) will always be in tension. However the introduction of psychological antecedents into the analysis of financial anomalies is not a negation of rational economic paradigm. The rational economic paradigm has to grow to account for observed reasons for behavior.

Uncertainty is inherently an emotion with negative valence because people are averse to uncertainty. Tactics to reduce uncertainty, for instance identification of patterns, serve an important motivational function (Raghubir and Das, 1999). Besides, ability attenuates information processing biases. Thus experts are less prone to non normative information processing and more normative decisions are possible with less time pressure (Raghubir and Das, 1999).

Investors could use herding as a mechanism to protect them from uncertainty when they behave irrationally. Besides, herding becomes relevant when such behavior is able to persist through time. Two related criteria must be considered to justify behavior persistence (Daniel and Titman, 1999). The first criterion is that biases would remain if they produce benefits that cannot be eliminated over a long period of time by natural selection; The second criterion is that biases that systematically make individuals less successful investingshould not play a role in setting securities prices. In the presence of

herding we observe offsetting benefits' because it is related with cycles. Furthermore, when investors herd all individuals do the same which avoids the comparison between the most and less successful. .

Subjects display less regret when the bias affects a large amount of people (regret bias). Consequently, herding behavior will depend not only on the uncertainty present in the market, but also on each investor's individual perception about the level of uncertainty surrounding them. Thus, for example, in the same informational context investors who are more insecure and less confident about their sources of information will have a greater propensity to herd. This feeling of uncertainty is a characteristic of each individual, since it will depend on each individual's attitudes, their more or less intuitive character, their risk propensity, their excess or lack of confidence, their illusion of control, their degree of tolerance for ambiguity, and so on. All these variables, which are interrelated, make up the investor's cognitive profile, which determines how the individual receives and interprets the different information stimuli they receive from their environment. Consequently, individuals' cognitive profiles will also be determinant in explaining in what circumstances investors decide to ignore their private information and imitate majority decisions in the market.

Recognizing the importance of the cognitive profile in explaining herding behavior, the difficulty now lies in how to measure this profile and consequently represent it in variables. This problem is resolved by using the biases in individuals' behavior and the rules of thumb as proxies of the cognitive profile. The literature identifies a wide variety of biases and rules of thumb, which originate in individuals' need to simplify their decision problems because of their cognitive limitations and emotions (Hirshleifer, 2001).

The current work aims to explain the herding phenomenon on the basis of investors' cognitive profile, so it concentrates on those biases that could be more directly linked to this phenomenon (because they favor or limit herding): illusion of control, overconfidence, self-attribution, and hot-hand and gambler's fallacies. After identifying the cognitive profile of the subjects, the objective is to analyze whether this profile is responsible for investors' herding behavior (Hirshleifer and Teoh, 2003).

Individuals suffering from the *illusion of control* bias think they can control and influence totally random events underestimate the role of chance and perceive games of chance as games of skill (Langer, 1975; Kahneman and Riepe, 1998). Such individuals believe that other investors are similarly affected. Thus, these investors infer

information from the decisions taken by other individuals under the assumption that those individuals have made their decisions based on relevant information and not randomly. Consequently, the illusion of control encourages herding.

Overconfidence occurs when subjects systematically overestimate their capacity to resolve situations compared to the rest of the individuals, overvalue their decisions and overestimate their own knowledge (Daniel *et al.*, 1998; Dittrich *et al.*, 2005). Overconfidence can lead individuals to put too much weight on their own private information and too little weight on any other information available (Chuang and Lee, 2006). They act following their own private signals, and ignore cascades (Bernardo and Welch, 2001). Investor overconfidence can generate momentum in stock returns and this momentum is likely to be strongest in those stocks whose valuations require the interpretation of ambiguous information (Daniel and Titman, 1999). Experts tend to be more overconfident than relatively inexperienced individuals (Griffin and Tversky, 1992). Besides, overconfidence is generally stronger for more diffuse tasks for which feedback is slow than for more mechanical tasks that provide immediate outcome (Einhorn, 1980). Overconfidence conceivably reduces herding behavior.

When individuals look back and assess their estimations and decisions, they are generally affected by a series of biases known as hindsight bias, including *self-attribution*. Self-attribution bias exists when the individual attributes events that validate their actions to their own skill and events that do not validate their actions to external agents (Fischhoff, 1982). Thus, individuals affected by self-attribution will not imitate others unless they have had a long run of poor decisions.

The hot-hand and the gambler's fallacies are related to the representativeness heuristic (Rabin, 1998). According to Chan *et al.* (2002: 1), "almost invariably, the human information processing bias that underlies a given model of market inefficiency is a variation of the representativeness heuristic". The representativeness heuristic occurs when a person establishes the probability of an event in function of the degree to which it is similar in its essential characteristics to a population (Kahneman and Tversky, 1974). Representativeness heuristic gets more room in uncertainty. The biases committed when using the representativeness heuristic include the gambler's fallacy, whereby the individual assumes that the future random behavior of an asset necessarily depends on its past performance. Specifically, the subject sometimes considers randomness as a self-correcting process in which a deviation in one direction induces a deviation in the opposite direction to restore the equilibrium (Rabin, 1998). These

individuals consequently have the mistaken belief that random sequences should exhibit systematic reversals (Bar-Hillel and Wagenaar, 1991). In other cases, the representativeness heuristic involves people expecting too few lengthy streaks in random sequences and hence they think that those streaks are not justified by mere chance (hot-hand fallacy). Thus, the hot-hand fallacy encourages herding, since after observing various buy (sell) transactions in the market, the investor thinks that the trend will continue and decides to buy (sell) as their predecessors have done. In contrast, gambler's fallacy inhibits herding since the individual decides to trade in the opposite direction to that of the recent trend (Rabin and Vayanos, 2009).

Then, as the amount of information increases investors will be guided by their emotions and follow the mood of the market rather than transform the information into knowledge to avoid regret. Thus, the second hypothesis is as follows:

> H_2: Investors' cognitive profile, defined as the result of a combination of biases, conditions their feeling of uncertainty and their herding behavior.

However, not all biases foster herding. Those subjects for whom illusion of control and hot hand fallacy dominates overconfidence and gambler's fallacies are more prone to herding. Thus, we identify five sub hypotheses from the expected relation between each bias and herding:

H_{2A}: Illusion of control bias favors herding

H_{2B}: Overconfidence bias reduces herding

H_{2C}: Self-attribution bias reduces herding

H_{2D}: Hot-hand fallacy encourages herding

H_{2E}: Gambler's fallacy inhibits herding

Finally, investors habitually react disproportionately when they receive new information in the market, *under*- or *over-reacting* (DeBondt and Thaler, 1985; Hong and Stein, 1999). The level of underreaction varies with information uncertainty (Burghof and Prothmann, 2009). There is evidence that the initial market reaction to new public information is incomplete. The degree of incompleteness of the market reaction increases monotonically with the level of information uncertainty. If investors underreact to public information, they will underreact even more in cases of greater

information uncertainty (Zhang, 2006; Hirshleifer, 2001). On the other hand, Angelini and Guazzarotti (2009) find scarce evidence that higher uncertainty will cause prices to react more slowly to news. Then, there is no agreement in the literature about the relation between information uncertainty and speed of adjustment of stock prices to news. Further empirical analyses are required to solve the question of underreaction to new public information.

Then, the research considers, simultaneously, uncertainty and investors' cognitive profile, to find an empirical answer about the question of investors' underreaction to new public information. If individuals imitate their predecessors' decisions buying or selling, they over-react to the public information, however if individuals imitate their predecessors' decisions of not acting they under-react to the public information. Acting or not could be is affected by information uncertainty. Thus, the third hypothesis is:

> H_3: Investors' under reaction to new information explains herding conditioned by information uncertainty

3. EXPERIMENTAL AIMS AND DESIGN

The herding issue has been analyzed either using market data and regression analysis or experiment with students (Bikhchandani and Sharma, 2001). In our case, we needed to observe individuals' behavior in a controlled way, so the empirical application of this research is based on an experimental setting. The main advantage of a laboratory experiment over market data is that the experiment allows to control for public and private information and thus to make explicit tests of theoretical predictions more easily (Alevy *et al*, 2007). Experiments provide a way to investigate behavior absent many of the confounding effects present in field studies (Brown and Kagel, 2009). Besides, theory driven experimental analysis will allow clarification among competing explanations and should complement existing empirical paradigms (Raghubir and Das, 1999). Finally, experimental inquiry based on psychological theoretical models is the route to follow to complement the inductive explanation of errant data patterns with a deductive prediction of behavior. Theory driven experimental inquiry has the potential to provide a unique understanding of how people make financial decisions (Raghubir and Das, 1999)

Economics recognize the importance of using experiments to supplement existing normative modeling and descriptive field research (Plott, 1991a, 1991b). Laboratory experiments have been used to address the behavior of financial markets in the fields of economics and psychology (Andreassen, 1988; Myagkov and Plott, 1997; Noussair *et al.*, 1995, 1997) but experimentation has yet to become a mainstream exercise in finance. Experimental inquiry is the single most appropriate methodological tool for isolating causes of behavior and for complementing existing empirical paradigmatic approaches in behavioral finance (Raghubir and Das, 1999).

Our experiment considers herding irrational because it centers on investor psycology and economizing on information processing by using heuristics. The experimental design rules out the imperfect information, the concerns for reputation and compensation structures issues that Bikhchandani and Sharma (2001) propose to justify rational herding. In our experiment setting, subjects decide while confounding factors are held constant across different information settings. This allows us to differentiate behaviors that are otherwise difficult to disentangle (Bloomfield, *et al*, 2005). We focus on a transaction that is easily categorized as having a positive impact on the price of the stock and occurs fairly frequently.

The experiment consisted of two sessions. The first had the aim of analyzing the relation between information and herding behavior, while the second analyzed the influence of the behavioral biases on herding behavior under different levels of information.

The two sessions of the experiment took place in the premises of our laboratory. A total of 56 people participated in each session, all of whom were university students studying Business Administration. Subjects were recruited using a public announcement and were rewarded in relation to their performance by being given tickets. Subjects received a total of 21041 tickets, the best performer being given 1166 tickets and the worst 17. First prize was a laptop computer worth €700, while the remaining prizes were cash sums of €100, €50 and €10. Prizes were assigned through a random lottery with all the participants' tickets. Those with more tickets had more chances to win the best prizes, as was the case. The average payment to participants was €38.

Bikhchandani and Sharma (2001) argue that to examine herd behavior one needs to find a group of participants that trade actively and act similarly. Our sample is a set of Business Administration students from the last two degree years. Such condition looks

for subjects with basic finance knowledge and familiarized with trading in financial markets.

One could argue that market professionals would be a better sample for our purposes. However, Alevy *et al*, (2007) indicate that market professionals are less Bayesian than students. Students are much likely to be Bayesians in the symmetric treatment. Then using students does not bias the results in favor of non rational herd behavior. In aggregate, the rate of cascade formation is not significantly different for students and for market professionals (Alevy *et al*, 2007). It is true that market professionals learn from experience more than students do (Menkhoff *et al*, 2006) but in our experiment experience is not an issue.

Alevy *et al*, (2007) present evidence on the prevalence of non Bayesian decision heuristics, an area in which the two subjects' pools, professionals and students, demonstrate similarities. Then, our sample of Business Administration students is a nice fit for our experiment since students are more Bayesian than professionals, have basic finance knowledge and they understand the functioning of financial markets.

3.1 Session I: Information uncertainty and herding

Cognitive biases are the object of study in experimental psychology. Several studies have shown that those biases diminish if information is expressed in numerical frequencies or posed in visual formats. However, there is no guarantee that financial decisions problems will be presented to individuals in a manner that favors the most accurate decisions (Hirshleifer, 2001). Investors may herd if they ignore their private information signals in deciding (Hirshleifer and Teoh, 2003), such behavior could show up as: Whether to participate in the market; What securities to trade; and/or Whether to buy or sell. People may be looking for trends in data where no trends exist because trends imply the future is predictable so one can have control over future outcomes and thereby reduce uncertainty. In our experiment subjects are paid more if they behave rationally, it means they acknowledge changes in prices are random. Besides, because additional public information can encourage individuals to fall into a cascade sooner (Hirshleifer and Teoh, 2003) we have identify three levels of public information. As the public pool of information grows, individuals' actions become less sensitive to private signals. However, if the public pool of information is uninformative, actions are sensitive to private signals (Hirshleifer and Teoh, 2003)

To test the hypothesis about the relation between uncertainty and the herding phenomenon, the authors established three treatments that differ in the amount of public information available. Each of the treatments reproduces different levels of public information (see Table 1). In the three treatments, the participants must decide if they wish to buy or sell a stock, or do nothing, given the current market price and the public and private information provided in each of the situations, known as rounds (see Appendix with the instructions). Subjects do not act sequentially. Thus, information concerning previous decisions by the remaining investors is provided by the experiment manager. This information is generated randomly. Using this design, our aim was to analyze subjects' behavior in the experiment vis-à-vis different types of information to identify who herds in each scenario. Subjects receive no feedback on their actions to avoid influencing our results with learning experience.

In each treatment there are 40 rounds. Each round can have from three to ten transactions, since at least three transactions are needed to observe imitation among investors, whereas ten transactions could be enough to reach the equilibrium point in the stock market price. Each of the 56 subjects acts only in the final transaction of each round. The decision in each round is independent of the decisions taken in the other rounds to isolate herding behavior.

The underlying value of the stock in each round can be either 0 or 100 ducats, and this is decided randomly before each round of transactions begins. There is a 50 percent chance that the stock will be worth 0 ducats, and a 50 percent chance that it will be worth 100 ducats. It should be stressed that the subjects do not know for certain the underlying value of the stock at any time, they only have market price information. The price in each transaction is calculated through Bayes' Law. However, subjects receive no explanation about this procedure when fixing their prices. They are informed that the price of the stock changes from transaction to transaction according to the investor's decision, as occurs in capital markets. When individuals buy a stock, the price rises, when they sell, the price falls, and when they do nothing, the price remains the same.

One objective of the session is to analyze the presence of herding among the investors, so the researchers design the experiment to give the subjects information that enables them to take the same decisions as other individuals. The public information is different in each of the three treatments in the experiment. In the first treatment—"high uncertainty"—the participants must decide whether to buy, sell or do nothing, when they know the current price of the stock and its prices in previous periods (transactions).

In the second treatment—“moderate uncertainty”—the investors have public information about the prices in the previous transactions and about the investors’ actual decision: bought, sold or did nothing. These two treatments differ in the stimuli used to provide the same information. Finally, in the “low-uncertainty” treatment the investors have public information about the prices in the previous periods, the transactions carried out, and the analysts’ consensus recommendations. These recommendations are generated randomly because the relevant point is the availability of information provided by financial experts. The analysts’ experience in the market may mean that the participants perceive them to be a source of reliable knowledge. The uncertainty diminishes from treatment to treatment as the public information available to the subjects increase.

To prevent the possible presence of spurious herding from contaminating the results, private information is introduced to serve as a filter (Cipriani and Guarino, 2005). The private information given to the participants in the experiment informs them about the intrinsic value of the stock (market price is the public information) and is the same in all the three treatments. This private information will be favorable if the underlying value of the security is 100 ducats, and unfavorable if the underlying value is 0 ducats. To reproduce investors’ insecurity about the reliability of their information, the participants do not know for certain at any time if the private information they have is true or not, since this information can come from either a “Truth-teller” or a “Fibber”, each with equal probability. Truth-tellers give reliable information in 70 percent of the cases, while Fibbers give reliable information in only 30 percent of the cases. Our goal is to evidence that a subject who acts rationally will find that there is the same probability that the information is true or false. It then depends on a subject’s cognitive profile whether they believe the information to be true or false.

Thus, when both types of information —public and private— induce the individual to take the same decision, it is impossible to determine what type of information has had the greatest weight in the individual’s decision-making. In other words, it is impossible to know whether the individual has imitated the other investors’ decision or followed their own private information. These situations only act as a control, allowing the researchers to ensure that the participants respond coherently; they cannot consider them in the subsequent analysis of herding. Only when the public and private information induce the investor to take opposite decisions and the investor decides to

follow the public information and ignore their private information can intentional herding be said to exist.

In order to analyze the relation between herding behavior and level of uncertainty, each individual's proportion of imitation in each treatment was calculated taking into account only those situations that exclude the possibility of spurious herding.

The variables HERD1, HERD2 and HERD3 measure the level of herding propensity for each subject in the three treatments in the analysis: high, moderate and low uncertainty. This is followed by difference of means tests and Wilcoxon signed-ranks tests to accept or reject the first hypothesis that the level of uncertainty explains investors' herding behavior.

3.2 Session II: Information uncertainty, behavioral bias and herding

The second session of the experiment aims to detect the presence of certain biases in the individual's behavior. The aim of this stage in the experiment is to analyze the effect on herding behavior of the following cognitive profile variables (see Table 1): illusion of control (ILC), gambler's fallacy (GF), overconfidence (OC), self-attribution (SA), and hot-hand fallacy (HHF). The research considers how under-reaction to new information (UR) influences herding conditioned by information uncertainty. To identify how the subjects present the proposed biases we design the test of preferences questionnaire (see Appendix) based on the works of Kahneman and Riepe (1998), Kahneman and Tversky (1974 y 2000) and Montier (2002). Some of the questions included in our test of preferences are a selection of questions included in the papers quoted, modified to take into account the environment and culture of Spain. The rest of the questions are new with the goal of introducing theoretical considerations related with our paper. Then, this test presents the participants with different real life situations and the participants must decide which of the proposed actions they would take.

With the aim of looking further at the relation between the variables measuring the behavioral biases and herding behavior, the researchers first carried out an analysis of variance (ANOVA) and then a binary logistic regression (LOGIT). We are aware that the cognitive variables are not mutually exclusive, and for this reason the latter analysis allows us to consider the interrelations between the cognitive variables chosen in the present study. They observed the reaction of the subjects in those situations in which the private information contradicts the public information in order to calculate the extent to

which each individual imitates. Then, from the original variables (HERD1, HERD2, and HERD3) the researchers build new dummy variables (G-HERD1, G-HERD2, and G-HERD3), to divide the subjects into two groups: high herding intensity and low herding intensity, for each of the information treatments. Specifically, the frequency distribution of the original variables is split into two blocks depending on whether the value of the variable exceeds the median or not[2]. Block 1 contains individuals that show a low intensity of imitation behavior, while Block 2 contains individuals who show a high intensity of imitation behavior. Thus, there are now three variables, one for each treatment, with two possible values that place each individual in either Block 1 or Block 2. The logit analysis is used to study whether the variables measuring the behavioral biases can explain this grouping.

- INSERT TABLE 1 -

4. RESULTS

4.1 Session I: Information uncertainty and herding

In the first stage of the analysis herding gradually diminishes as the uncertainty falls (see Table 2). Thus, the average individuals' imitation values observed in the high-uncertainty treatment (HERD1) is 0.31, and this drops to 0.29 in the moderate-uncertainty treatment (HERD2), and to 0.27 in the low-uncertainty treatment (HERD3). The test of mean differences shows that the fall in herding between the high and low uncertainty treatments is statistically significant at the 90 percent level (t=1.793) (see Table 2). The results from the Wilcoxon signed-rank test confirm these results, since they show a statistically significant difference in herding between the high and low uncertainty treatments (see Table 2). Hypothesis H_1, which postulates that herding behavior is more frequent in contexts of higher levels of uncertainty, is consequently accepted.

- INSERT TABLE 2 -

4.2 Session II: Information uncertainty, behavioral bias and herding

[2] The peculiar frequency distribution in the original variables prevents the blocks from capturing exactly 50 percent of each variable

The second stage of the analysis focuses on the dependence relations between the individual behavioral biases (explanatory variables) and herding in each of the three information treatments (dependent variable). Table 3 shows the results from the difference of means test.

- INSERT TABLE 3 -

The results show interaction relations between the variables measuring behavioral bias and herding in the different treatments. Thus, for the high and moderate uncertainty treatments, the variables measuring the cognitive profile barely have explanatory power, while the significance of the variables improves considerably in the low-uncertainty treatment.

Specifically, in the high-uncertainty treatment only the variable measuring gambler's fallacy is significant[3] in explaining the allocation of individuals to the low or high intensity imitation blocks. The results show that the individuals allocated to Block 2 (high-intensity imitation) on average show lower values in the gambler's fallacy variable (see Table 4). Thus, this variable is inversely related to herding behavior, as was expected. In turn, in the moderate-uncertainty treatment under-reaction is associated with herding behavior. An inverse relation exists between the presence of the under-reaction and herding.

- INSERT TABLE 4 -

Finally, in the low-uncertainty treatment, the variables associated with herding behavior are illusion of control and self-attribution. Comparing the mean values of these variables in the two blocks, the results show that the individuals in the high-intensity imitation block show on average less self-attribution and greater illusion of control.

The logit analysis confirms most of the previous results about the dependence relation between the cognitive profile variables and herding. Specifically, the dependent variable is the variable measuring the block to which the individual is allocated in function of their low or high imitation intensity. This variable is available for each of the three

[3] The significant variables include not only those with confidence levels exceeding 95 percent but also those with confidence levels exceeding 90 percent. The reason is because, as mentioned above, the limited number of individuals weakens the statistical power of the analysis.

treatments considered (G-HERD1, G-HERD2 and G-HERD3). The procedure used was stepwise estimation, which allows the researcher to detect the most important independent variables.

The results obtained in the logit analysis for the high and moderate uncertainty treatments show that the behavioral bias variables have little explanatory power, and this means the model cannot be estimated (Table 5). These results show that the power of uncertainty to provoke herding behavior prevails over the individual's characteristics.

- INSERT TABLE 5 -

In the low-uncertainty treatment, however, the results of the logit analysis are statistically significant. Here the cognitive profile variables are statistically significant and they permit estimation of the empirical model. The maximum likelihood ratio test confirms the goodness of fit of the model, since its value exceeds the chi square with four degrees of freedom at the most demanding confidence levels. Hence the deduction is that the allocation of individuals to the high or low intensity imitation block is explained by the behavioral bias variables considered in the analysis (cognitive profile). Four of the variables are significant: illusion of control (ILC), self-attribution (SA), under-reaction (UR) and overconfidence (OC). The associated signs indicate that the individuals allocated to the high-intensity imitation block show higher levels in illusion of control, overconfidence and under-reaction, and a lower level of self-attribution. In other words, in the low-uncertainty treatment the illusion of control, overconfidence and under-reaction biases have a positive relation with the herding phenomenon, while the self-attribution bias has an inverse relation with this behavior. These signs are consistent with those obtained in the previous difference of means analysis.

In contrast to what was expected, the hot-hand and the gambler's fallacies are not significant in the logit analysis for any of the treatments. Several reasons may explain this result. These variables may not be accurately measuring the bias as intended, or their effect may interact with some of the other variables in the analysis. On the other hand, in low-uncertainty contexts individuals with a tendency to under-react and be over-confident could behave unexpectedly. In this type of situation, these individuals interpret that the rest of the investors have no difficulty in taking decisions, given the variety of stimuli and information sources available, and consequently accept the trading observed in the transaction history as ideal. Hence they imitate the other

investors, and letting oneself get carried along by the investors' mood predominates over individual biases contrary to herd behavior. This is the situation that is usually seen in periods experiencing bubbles in the financial markets. The prices keep rising irrationally, and there is nothing to counter the rise, not even the individual biases that counteract herding behavior. This finding could explain why speculative bubbles form in the financial markets despite the fact that over-confident individuals should stop them from appearing or slow them down if they do appear. The current results could indicate that in a low-uncertainty environment, individuals who show biases that counter herding let themselves be carried along by the rest of the individuals and imitate, thereby favoring the creation of bubbles. In short, even the behavioral biases differ in function of the uncertainty.

Globally, the current results confirm the influence of the behavioral biases on the phenomenon of herding, which provides support for Hypothesis H_2. But this relation is more complex than a simple dependence relation, since it only becomes visible in low-uncertainty contexts. Specifically, the results show that in uncertain contexts the weight of the uncertainty generates herding independently of differences between individuals. This confirms that the weight of the uncertainty hides the influence of the individual behavioral biases. But in low-uncertainty contexts, in which the general tendency to herd is lower, it is the inter-individual differences that can explain individuals' differing herding propensities. Thus, the results show that both environmental uncertainty and individuals' behavioral biases are determinants of the herding phenomenon, and in addition, the two determinants interact with each other. In other words, the fall in the level of uncertainty exposes the effect of the biases on herding behaviors. This confirms the complexity of the relations that exist between the determinants of herding behavior.

5. FINAL REMARKS

Investors' herding behaviors in financial markets originate in informational limitations: either the investors lack part of the information or they are unable to process the information available and turn it into knowledge. In an uncertain environment, where perfect information does not exist, the feeling of uncertainty leads individuals to think that others are better informed. The greater the investors' sensation of uncertainty is, the more they doubt their own information. Consequently, in uncertain environments investors try to obtain information by observing the financial decision-making of the

rest of the participants in the market. The deduction that follows from this is that the higher the level of uncertainty, the higher the investors' propensity to imitate other individuals' decisions.

Along with the uncertainty in the financial decision-making, the individuals are also affected by cognitive limitations and subject to the influence of their own beliefs, attitudes and cognitive profile. Thus, individuals are not always going to behave as homogenous and perfectly rational agents. Consequently, responses to market signals vary considerably from one investor to the next. This makes it necessary to study how investors' individual profiles affect their herding behavior. The current work analyzes whether the presence of biases in individuals' behavior affects the intensity of their herding behavior.

The results obtained in the experiment carried out here offer new evidence about the factors intervening in the herding phenomenon in financial markets. On the one hand, they show that uncertainty, and consequently informational limitations, favors herding among investors. The results show that herding behavior reaches a peak in environments with a higher level of uncertainty. They also show that in the moderate and high uncertainty treatments, personal differences cannot explain the different intensity levels of imitation among individuals. A rise in uncertainty homogenizes individual behavior with respect to the herding phenomenon. But as the uncertainty falls, individuals' cognitive profiles become more important in explaining herding behavior. Moreover, the nature of the individual biases that affect herding behavior also changes as uncertainty falls. This result helps explain, for example, why, in the final moments of the bubbles that form in financial markets, as the influence of the elements that counteract market irrationality weakens, asset prices accelerate upwards far above their real value. Thus, two conclusions can be drawn from this research: First, the dependence relation between feeling of uncertainty, investors' behavioral biases and the herding phenomenon; Second, the determinants of herding—information and behavioral biases—are interrelated. Specifically, the presence of high levels of uncertainty favors herding behaviors, regardless of the inter-individual differences. Only when the level of uncertainty falls is the effect of the behavioral biases determinant in investors' herding behavior.

In short, the current results confirm that the herding phenomenon is complex, since factors of a very diverse nature intervene. Future research should examine further the

best way to measure the individual's cognitive profile and its interaction with information limitation in financial markets.

6. REFERENCES

Alevy, J. E., M. S. Haigh and J. List (2007). "Information cascades: evidence from a field experiment with financial market professionals", *The Journal of Finance* 62, 1, 151-180.

Allen, F., S. Morris and A. Postlewaite (1993). "Finite bubbles with short sale constraints and asymetric information", *Journal of Economic Theory* 61, 206-229.

Allen, F., S. Morris and H.S. Shin (2006). "Beauty contests and interacted expectations in asset markets", *The Review of Financial Studies* 19, 3, 719-752.

Andreassen, P.B. (1988). "Explaining the price volume relationship: The difference between price changes and changing prices", *Organization Behavior and Human Decission Processes* 41, 3, 371-389.

Angelini, P. and G. Guazzarotti (2009). "Information uncertainty and the reaction of stock prices to news", *SSRN* 1342672.

Avery, C. and P. Zemsky (1998). "Multidimensional Uncertainty and Herd Behavior in Financial Markets", *American Economic Review* 88 (4), 724-748.

Banerjee, A.V. (1992). "A Simple Model of Herd Behavior". *Quarterly Journal of Economics* 107 (3), 797-817.

Bar-Hillel, M. and W.A. Wagenaar (1991). "The Perception of Randomness". *Advances in Applied Mathematics* 12 (4), 428-454.

Barberis, N. and R. Thaler (2003). "A Survey of Behavioral Finance" in *Handbook of the Economics of Finance*, ed. by H. M. Constantinides, G. and R. Stulz, 1051-1121. Elsevier Science B.V.

Bernardo, A.E. and I. Welch (2001). "On the Evolution of Overconfidence And Entrepreneurs", *Journal of Economics and Management Strategy* 10 (3), fall 2001, 301-330.

Bikhchandani, S., D.A. Hirshleifer. and I. Welch (1992). "A Theory of Fads, Fashion, Custom and Cultural Change as Informational Cascades", *Journal of Political Economy* 100 (5), 992-1026.

Bikhchandani, S. and S. Sharma (2001). "Herd Behavior in Financial Markets: A Review". *IMF Staff Papers*. 47 (3), 279-310. International Monetary Fund.

Bloomfield, R. J., O. Maureen and G. Saar (2005). "The Limits of Noise Trading: An Experimental Analysis", *NYU Working Paper* nº FIN-05-015. Available at SSRN: http://ssrn.com/abstract=1294151

Brown, A. L. and J.H. Kagel (2009)**.** "Behavior in a simplified stock market: the status quo bias, the disposition effect and the ostrich effect", *Annals of Finance* 5, 1-14.

Burghof, H.P. and F. Prothmann (2009)**.** "The 52 week high strategy and information uncertainty", *SSRN* 1374762.

Chari, V.V. and P.J. Kehoe (2004). "Financial crises as herds: Overturning the critiques", *Journal of Economic Theory* 119, 128-150.

Chan, W.S., R.M. Frankel and S.P. Kothari (2002). "Testing Behavioral Finance Theories Using Trends and Sequences in Financial Performance", *MIT Sloan School of Management Working Paper* 4375-02, http://papers.ssrn.com/sol3/results.cfm?nxtres=61.

Chen, Q. and W. Jiang (2006). "Analysts' weighting of prívate and public information", *The Review of financial studies* 19, 1, 319-355.

Chuang, W.I. and B.S. Lee (2006) "An Empirical Evaluation to the Overconfidence Hypothesis", *Journal of Banking and Finance*. 30 (9), 2489-2515.

Cipriani, M. and A. Guarino (2005). "Herding And Price Convergence in a Laboratory Financial Market", *American Economic Review* 95 (5), December, 1427-1443.

Cipriani, M. and A. Guarino. “Transaction Costs and Informational Cascades in Financial Markets: Theory and Experimental Evidence”. *ECB Working Paper* nº 736. http://ssrn.com/abstract=965422.

Daniel, K., D. Hirshleifer. and A. Subrahmanyam (1998). “Investor Psychology and Security Market Over- and Underreactions”. *Journal of Finance* 53, 1839-1885.

Daniel, K. and S. Titman (1999). “Market efficiency in an irrational world”, *Financial Analysts Journal* 55 (6), 28-40.

DeBondt, W.F. and R.H. Thaler. (1985). “Does the Stock Market Overreact?”. In *Advances in Behavioral Finance*, ed. Richard H. Thaler (1993), 249-264.

DeBondt, W., G. Muradoglu, H. Shefrin and S.K. Staikouras (2008). “Behavioral Finance: Quo Vadis?” *Journal of Applied Finance*, 1-15.

Devenow, A. and I. Welch (1996). “Rational herding in financial economics”, *European Economic Review* 40, 603-615.

Dittrich, D., W. Güth and B. Maciejovsky (2005). “Overconfidence in Investment Decisions: An Experimental Approach”. *The European Journal of Finance*, 11 (6,) December, 471-491.

Einhorn, H.J. (1980). “Overconfidence in judgement”, *New Directions for Methodology in Social and Behavioural Sciences* 4, 1, 1-16.

Fischhoff, B. (1982). “For Those Condemned to Study the Past: Heuristic and Biases in Hindsight” in *Judgement under Uncertainty: Heuristics and Biases*, ed. D. Kahneman, P. Slovic and A. Tversky, Cambridge University Press.

Froot, K., D. Scharfstein and J. Stein (1992). “ Herd on the street: Informational inefficiencies in a market with short term speculation”, *Journal of Finance* 47, 4, 1461-1484.

Graham, J.R. (1999). “Herding Among Investment Newsletters: Theory and Evidence”. *Journal of Finance* 54, 237-268.

Griffin, D. and A. Tversky (1992). “The Weighing of Evidence and the Determinants of Confidence”,. *Cognitive Psychology* 24, 411-435.

Hirshleifer, D. (2001). “Investor Psychology and Asset Pricing”, *Journal of Finance* 56, 1533-1598.

Hirshleifer, D. and G.Y. Luo (2001). “On the Survival of Overconfident Traders In A Competitive Securities Market”, *Journal of Financial Markets* 4, 73-84.

Hirshleifer, D. and S.H. Teoh (2003). “Herd Behavior and Cascading in Capital Markets: A Review and Synthesis”, *European Financial Management* 9, nº 1, 25-66.

Hong, H. and J.C. Stein (1999). “A Unified Theory of Underreaction, Momentum Trading and Overreaction in Asset Markets”, *Journal of Finance* 54, 2143-2184.

Kahneman, D. and M.W. Riepe (1998). “Aspects of Investor Psychology”, *Journal of Portfolio Management* 24, 52-65.

Kahneman, D. and A. Tversky (1974). “Judgment under Uncertainty: Heuristics and Biases”, *Science* 185, 1124-1131.

Kahneman, D. and Tversky, A. (2000): Choices, Values and Frames. Cambridge University Press.

Keynes, J.M. (1936). The *general theory of employment, interest and money*, McMillan, London.

Lakonishok, J., A. Shleifer and R.W. Vishny (1992). “The Impact Of Institutional Trading On Stock Prices”, *Journal of Financial Economics* 32 (1992), 23-43. North-Holland.

Langer, E. (1975). “The Illusion of Control”, *Journal of Personality and Social Psychology* 32, 311-328.

Menkhoff, L., U. Schmidt and T. Brozynski (2006). “The impact of experience on risk taking, overconfidence and herding of fund managers: Complementary survey evidence”, *European Economic Review* 50, 1753-1766.

Montier, J. (2002): Behavioral Finance: Insights into Irrational Minds and Markets. John Wiley & Sons, Ltd., Chichester, England.

Myagkov, M. and C.R. Plott (1997).”Exchange economies and loss exposure: Experiments exploring prospect theory and competitive equilibria in market environments”, *American Economic Review* 87, 5, 801-828.

Noussair, C., C.R. Plott and R.G. Rieman (1995). “An experimental investigation of the patterns of international trade”, *American Economic Review* 85, 3, 462-491.

Noussair, C., C.R. Plott and R.G. Rieman (1997). “The principles of exchange rate determination in an international finance experiment”, *Journal of Political Economy* 105, 4, 822-861.

Oechssler, J., A. Roider and P.W. Schmitz (2008). “Cognitive abilities and behavioral biases”, *IZA* discussion paper 3481.

Parker, W.D., and R.R. Prechter (2005). “Herding: An Interdisciplinary Integrative Review from a Socioeconomic Perspective”, *International Conference on Cognitive Economics. Sofia, Bulgaria. August 5-8, 2005.*

Plott, C.R. (1991a). ”Economics in 2090: The views of an experimentalist”, *Economic Journal* 101, 404, 88-93.

Plott, C.R. (1991b). “Will economics become experimental science?”, *Southern Economic Journal* 57, 4, 909-919.

Rabin, M. (1998). “Psychology and Economics”, *Journal of Economic Literature* 6, March , 11-46.

Rabin, M. and D. Vayanos, (2009). “The gambler’s and hot-hand fallacies: Theory and applications”, Working paper series SSRN number 954636

Raghubir, P. and S.R. Das (1999). “A case for theory-driven experimental inquiry”, *Financial Analysts Journal* 55, 6, 56-79.

Scharfstein, D.S. and J.C. Stein (1990). “Herd Behavior and Investment”, *American Economic Review*. 80, nº 3, 465-479.

Simon, H.A. (1957). Models of man: Social and rational, John Wiley and Sons, New York.

Wärneryd, K-E. (2001). *Stock-Market Psychology: How People Value and Trade Stocks*, Edward Elgar Publishing Limited. Cheltenham, United Kingdom.

Welch, I. (1992). “Sequential sales, learning, and cascades”, *Journal of Finance* 47, 695-732.

Wang, D. (2008). “Herd Behaviour towards the market index: Evidence from 21 financial markets”, *Working paper* WP-776 IESE Business School, University of Navarra.

Zhang, X.F. (2006). “Information uncertainty and stock returns”, *The Journal of Finance* 61, 1, 105-136.

Zeckhauser, R., J. Patel. and D. Hendricks (1991). “Nonrational Actors and Financial Market Behavior”, *Theory and Decision* 31, 257-287.

APPENDIX

First session. Instructions to participants.

Stage 1.

Operations simulating the buying and selling of various stocks by several investors are presented. You must decide in each situation whether to buy, or sell a particular stock, or do nothing. The intrinsic initial value of the share may be only 0 or 100 ducats, and it will be determined randomly before each round of transactions begins. There is a 50% likelihood that the stock will take one of these two values.

Although you will not know the intrinsic value of the stock obtained, you will be given certain private information regarding it. This private information will be favourable if the initial intrinsic value is 100 ducats, but will be unfavourable if the initial intrinsic value is 0 ducats. The problem is that you will not know for certain at any time whether the private information you have been provided with is accurate or not, as it is just as likely to come from one of two sources of information: a "Truth-Teller" or a "Fibber". Truth-Teller shows a 70% degree of reliability in the information provided, whereas Fibber only supplies news which are accurate 30% of the times.

The asset price will change from transaction to transaction depending on the decisions taken by investors: when subjects buy the share, the price rises and when they sell it, the price falls. If the investor does not trade, the price remains the same.

You will be faced with a variety of situations in which you must take a decision based on the current market price, the private information you have been provided with and the stock's prices in previous transactions.

The nature of the private information available to you (favourable or unfavourable) appears next to the number of the round in which you must decide. The stock's prices in previous periods is shown in brackets together with the corresponding transaction number. The price at which you may trade is shown next to the box in which you must indicate your decision to buy, sell or not trade.

EXAMPLE.

TRANSACTION	ROUND X Favourable private information	
1	(50 ducats)	
2	(70 ducats)	
3	(84 ducats)	
4	(70 ducats)	
5	(84 ducats)	
6	(93 ducats)	
7	(84 ducats)	
8	70 ducats	**C**

In round X you are the eighth participant who must decide. You should observe the stock's prices in the last seven transactions and take into account whether the private information available to you is favourable, suggesting that the price of the stock is 100 ducats (remember that you do not know from which of the two sources, Truth-Tellers or Fibbers, the information comes).

Bearing in mind all the information, you must decide whether to buy or sell the stock at 70 ducats (the price shown on the left of the last box in the column corresponding to round X), or do nothing. If you decide to **buy** the stock you should put a C in the right of the last box of the column for round X, meaning that you are willing to pay 70 ducats for a share which may be worth 0 or 100 ducats.

Stage 2.

At this stage of the experiment, the decisions you are faced with are similar to those in the previous stage, although now you will be given information which you did not have in stage 1. Now, you will be able to know whether the previous investors bought, sold or did not trade, as well as the price at which each of these transactions occurred. Therefore, when making your decisions, you must take into account the current market price, the private information and the new public information available.

EXAMPLE.

TRANSACTION	ROUND X Favourable private information	
1	Bought (50 ducats)	
2	Bought (70 ducats)	
3	Sold (84 ducats)	
4	Bought (70 ducats)	
5	Bought (84 ducats)	
6	Sold (93 ducats)	
7	Sold (84 ducats)	
8	70 ducats	**C**

In round X you are the eighth person who has to decide. You should observe the prices at which the seven previous investors traded together with the decision they took. Besides, you should take into account whether the private information available to you is favourable, indicating that the price of the stock is 100 ducats (remember that you do not know from which of the two sources, Truth-Tellers or Fibbers, the information comes).

Having examined all this information, you must decide whether to buy or sell the stock at 70 ducats (the price shown on the left of the last box in the column corresponding to round X), or do nothing. If you decide to **buy** the stock you should put a C in the right of the last box of the column for round X, meaning that you are willing to pay 70 ducats for a share which may be worth 0 or 100 ducats.

Stage 3.

At this stage of the experiment, the decisions you are faced with are similar to those in the previous stage, although now you will be given information which you did not know in stage 2. Now, you will be informed of the recommendations of certain analysts. When taking your decisions, you should therefore take into account the current market price, the private information, the public information available and the analysts' recommendations.

EXAMPLE.

TRANSACTION	ROUND X Favourable private information Recommendation: Sell above 50 ducats.	
1	Bought (50 ducats)	
2	Bought (70 ducats)	
3	Sold (84 ducats)	
4	Bought (70 ducats)	
5	Sold (84 ducats)	
6	70 ducats	**C**

In round X you must decide in sixth position. You should observe the prices at which the five previous investors traded and the decisions they took. You should also take into account whether the private information available to you is favourable, indicating that the price of the stock is 100 ducats (remember that you do not know from which of the two sources, Truth-Tellers or Fibbers, the information comes) and you should bear in mind that analysts recommend selling the stock if it is at a price of 50 ducats or more.

Having seen all of this information, you should decide whether to buy or sell the stock at 70 ducats (the price which appears on the left of the last box of the column corresponding to round X), or do nothing. If you opt to **buy** the stock you should put a C on the right of the last box in the column for round X, thus indicating that you are willing to pay 70 ducats for this stock.

Second session of the experiment. Preferences Test

Now mark with an arrow the response which most closely reflects how you would behave in the following situations:

1. You go to a casino to play roulette. When placing your bet:

a) You take into account the numbers which have been coming up in the previous spins, as you think that a number which has already won is less likely to win again.
b) You take into account the numbers which have been coming up in the previous spins because you think that if a number has won more than once it is more likely to win again.
c) You choose the number which appeals to you most at each spin.
d) You keep betting on the same number because you think that it must win eventually.

2. You want to invest in an investment fund. You have sought information about fund X and expect to it go up in the future, and as a result you consider investing in it.

2.a. A friend in the same situation recommends fund Y to you.

a) You decide to seek information about fund Y to confirm what your friend has told you and then to take a decision.
b) Your information about X is excellent and you feel it isn't worth wasting more time finding out about Y.
c) You feel you might be wrong and so decide to trust more in your friend's information and so invest in Y.

2.b. Finally you decided not to investigate further and invested in X. Your fund is now performing extremely badly due to the fact that one of its assets is suffering heavy losses following a financial scandal involving one of the firm's managers. What do you think in this case?

a) You should perhaps have listened to your friend.
b) I made the right decision because if it hadn't been for that scandal, the fund would now be returning a profit.

2.c. You decide to maintain your investment in fund X because you think that it will turn around. However, the fund continues to return losses over the following months. You think:

a) I made a mistake. I should not have maintained my investment in X.
b) I don't understand how the fund is still making a loss. The scandal has been cleared up and the firm in question has a new management team with an excellent reputation.
c) I am sure the fund will now start to pick up.

2.d. You invested in X and your friend in Y. Your friend's fund is suffering huge losses due to an unexpected change in the law in the sector to which several of the assets in the fund belong. You think:

a) Luckily I didn't listen to my friend. He was wrong and I wasn't.
b) Perhaps my friend made the right choice and was just unlucky with the changes in current legislation.

3. You held a stock which yielded surprisingly high returns over a period of several months but which has recently been showing a constant series of relatively small losses. Over the last week, however, the losses have become substantial. You think:

a) My stock has always shown a good price. If I wait for this bad patch to blow over the price is bound to go up again. I won't even listen to analysts' recommendations.
b) A renowned analyst warns you that the price of your share is likely to continue falling. You decide to sell the share.
c) The analyst warns you that the share will continue to fall, but because selling the share now means that you will make a loss, you decide to keep it.

4. The daily mean price of a particular share in recent weeks has been: 23, 20, 20, 21, 26, 26, 24, 20, 23, 22, 23, 28. You:

a) Decide to invest in the stock as it shows a general upward trend.
b) Decide to invest because over the last few days its share price has been going up.
c) Do not invest because you see no clear trend in the share price.

5. You hold 50 shares in a company which is rumoured to be considering a share issue due to the healthy state of the firm. You:

a) Decide to buy more shares in the firm before its price rises.
b) Ignore it when taking your decision as it is only a rumour.

6. You think that after finishing your university studies in order to find a job in line with your qualifications:

a) It will take you longer than most of your fellow graduates.
b) It will take you less time than most of your fellow graduates.
c) It will take you around the same time as most of your fellow graduates.

7. You decide to purchase a lottery ticket for the following Saturday's draw.

a) You go to the lottery ticket office and ask for a number ending in "your lucky number".
b) At the lottery ticket office you ask for a ticket without specifying any particular number.
c) Before going to the lottery ticket office you find out which numbers have been winning over the last few weeks.
d) You always buy the same number.

8. When deciding which assets to invest in, you prefer:

a) Stocks recommended by financial analysts.
b) Stocks which many investors are currently investing in.
c) Stocks about which you have gathered good information.

9. Pablo is 35, single, extremely brilliant and determined. After completing his university degree and several years training and hard work he was appointed to a post in a bank's portfolio management department. You think Pablo is more likely to be:

a) a graduate in Business Studies with a Master's Degree in Financial Markets
b) a graduate in Business Studies.

10. You go to a car dealer to buy a new car. You have been gathering information on the Duero and Ebro models. A mechanic you know and trust as well as specialised magazines seem to think that the Ebro model is a compact MPV more closely suited to your needs, but you prefer the more sporty Duero model.

When you visit the show room the dealer shows you the Tajo jeep, a new vehicle coming onto the market in a few weeks but which you have heard nothing about but which seems to offer excellent value for money. You:

a) Decide to buy the Duero model, the one you had first thought of.
b) Buy the Ebro model.
c) Wait until you have more information about the Tajo model.
d) Buy the Tajo model that very day.

11. You hold 50 shares in a firm about which rumours have been circulating to the effect that it is in serious financial difficulties. You:

a) Decide to sell before the rumours are confirmed, even if it means making a loss on the price you paid for them.
b) Ignore it when making a decision as they are just rumours.

12. Christmas is coming and you decide to purchase a lottery ticket for the Big Christmas Draw. When purchasing your ticket you see a sign listing the numbers which have won first prize in previous years (from 2005 to 1999): 20085, 54600, 42473, 08103, 18795, 49740, 65379.

a) Without stopping to read the above information you ask for a ticket ending in the number you already had in mind.
b) Ask for a ticket ending in 5, 0, 3 or 9, as these are the numbers which have been won in recent years.
c) Ask for a number ending in an even number or in 7, as these are the ticket number endings which have not won in recent years.
d) Buy any number.

13. You hold 80 shares in a firm about which bad rumours have been spreading. You:

a) Decide to sell the shares in the company before the price falls.
b) As it is only a rumour, you ignore it when taking your decisions.

14. When doing the weekly shopping at the supermarket, you:

a) Always buy products whose quality you are sure of and are reluctant to try new ones.
b) Buy articles which are on offer.
c) Buy articles recommended to you by friends and family.

TABLES

Table 1: Experiment sessions and variables		
Session I: Uncertainty and herding		
TREATMENT 1	**TREATMENT 2**	**TREATMENT 3**
Public information: • Price history	**Public information**: • Price history • Transaction history	**Public information**: • Price history • Transaction history • Consensus recommendations
Private information: Initial stock price: • Favorable: 100 Ducats • Unfavorable: 0 Ducats	**Private information**: Initial stock price: • Favorable: 100 Ducats • Unfavorable: 0 Ducats	**Private information**: Initial stock price: • Favorable: 100 Ducats • Unfavorable: 0 Ducats
Session II: Uncertainty, behavioral bias and herding		
Behavioral bias: ▪ Illusion of control (ILC) ▪ Overconfidence (OC) ▪ Self-attribution (SA) ▪ Under-reaction (UR) ▪ Hot-hand fallacy (HHF) ▪ Gambler's fallacy (GF)		

Table 2: **Mean imitation values, difference of means test and Wilcoxon signed-rank test**					
TREATMENT 1 **High uncertainty**	**TREATMENT 2** **Moderate uncertainty**			**TREATMENT 3** **Low uncertainty**	
0.3103	0.2856			0.2738	
	Difference of means t test			Wilcoxon signed-rank test	
	Mean	t	(Sig.)	Z	(Asympt. sig.)
High uncert. - Mod. uncert.	0.0246	1.324	(0.019)	-1.966	(0.049)
High uncert. - Low uncert.	0.0365	1.793	(0.079)	-1.832	(0.067)
Mod. uncert. - Low uncert.	0.0118	0.583	(0.563)	-0.057	(0.954)

Table 3:

Uncertainty, behavioral bias and herding. Results of difference of means test by treatment

	TREATMENT 1 High uncertainty	TREATMENT 2 Moderate uncertainty	TREATMENT 3 Low uncertainty
ILC	F: 0.002 (0.96)	F: 0.085 (0.77)	F: 3.34 (0.07)
OC	F: 0.158 (0.69)	F: 2.67 (0.10)	F: 1.18 (0.28)
UR	F: 0.079 (0.78)	F: 3.198 (0.07)	F: 2.766 (0.10)
SA	F: 0.733 (0.39)	F: 1.55 (0.21)	F: 5.80 (0.01)
HHF	F: 0.187 (0.66)	F: 1.42 (0.23)	F: 0.00 (0.98)
GF	F: 3.125 (0.08)	F: 1.71 (0.19)	F: 2.86 (0.096)

F is statistic of difference of means test. Significance level in parentheses.

Table 4:

Mean imitation in each uncertainty treatment and for each behavioral bias. Test of significance for mean differences

		Analysis of means (significant variables)			ANOVA (significant variables)	
	Variable	**Herding block**	**N**	**Mean**	**F**	**Sig.**
High-uncertainty treatment	**GF**	1 2 Total	26 30 56	0.2308 0.0667 0.1429	3.125	0.083
Moderate-uncertainty treatment	**UR**	1 2 Total	26 30 56	0.6410 0.4556 0.5417	3.198	0.079
Low-uncertainty treatment	**ILC**	1 2 Total	13 43 56	0.0577 0.1686 0.1429	3.342	0.073
	SA	1 2 Total	13 43 56	0.8846 0.6279 0.6875	5.801	0.019

Table 5: Uncertainty, behavioral bias and herding. Logit analysis

Model	HERD=β0+β1ILC+β2OC+β3SA+β4HHF+β5GF+β6UR

Estimation: High-uncertainty treatment

		B	T.E.	Wald	df	Sig.	Exp(B)
	Constant	.143	.268	.285	1	.593	1.154
-2 log L_0: 77.347							

Estimation: Moderate-uncertainty treatment

		B	T.E.	Wald	df	Sig.	Exp(B)
	Constant	.143	.268	.285	1	.593	1.154
-2 log L_0: 77.347							

Estimation: Low-uncertainty treatment

		B	T.E.	Wald	df	Sig.	Exp(B)
	ILC	8.637	3.604	5.742	1	.017	5634.965
	OC	8.538	4.659	3.358	1	.067	5102.887
	SA	-6.678	2.186	9.329	1	.002	.001
	UR	2.893	1.308	4.893	1	.027	18.053
	Constant	2.355	1.426	2.727	1	.099	10.535
-2 log L_0*: 60.687							
-2 log L_1: 34.889							
C: 25.798**							

* Model including only one constant.

** Maximum likelihood ratio test: C = - 2 log L_0/L_1 = - 2 (log L_0 – log L_1); Chi square with as many degrees of freedom as number of variables evaluated.