PONTIFÍCIA UNIVERSIDADE CATÓLICA DO PARANÁ
BUSINESS SCHOOL
GRADUATE PROGRAM IN BUSINESS ADMINISTRATION
DOCTORATE IN BUSINESS ADMINISTRATION

LEONARDO KÖPPE MALANSKI

SOCIAL TRANSMISSION BIAS: AN EXPERIMENTAL STUDY THROUGH THE WISDOM OF THE MINORITY

CURITIBA
2024

LEONARDO KÖPPE MALANSKI

SOCIAL TRANSMISSION BIAS: AN EXPERIMENTAL STUDY THROUGH THE WISDOM OF THE MINORITY

Doctoral thesis presented to the Graduate Program in Business Administration of Pontifícia Universidade Católica do Paraná, in partial fulfillment of the requirements for the degree of Ph.D. in Business Management, research area: Finance.

Advisor: Angela Cristiane dos Santos Póvoa, Ph.D.

Co-advisor: Wesley Pech, Ph.D.

CURITIBA

2024

Dados da Catalogação na Publicação
Pontifícia Universidade Católica do Paraná
Sistema Integrado de Bibliotecas – SIBI/PUCPR
Biblioteca Central
Luci Eduarda Wielganczuk – CRB 9/1118

M236s
2024

Malanski, Leonardo Köppe
Social transmission bias : an experimental study through the wisdom of the minority / Leonardo Köppe Malanski ; advisor: Angela Cristiane dos Santos Póvoa ; co-advisor: Wesley Pech. – 2024.
119 f. : il. ; 30 cm

Tese (doutorado) – Pontifícia Universidade Católica do Paraná, Curitiba, 2024
Bibliografia: f. 109-113

1. Administração de empresas. 2. Viés de transmissão social. 3. Cascata de informação. 4. Processo decisório. 5. Estudo observacional. I. Póvoa, Angela Cristina dos Santos. II. Pech, Wesley. III. Pontifícia Universidade Católica do Paraná. Programa de Pós-Graduação em Administração. IV. Título.

CDD. 20. ed. – 658.4

DocuSigned by:
Leonardo Köppe Malanski
D71BD4FCC48B4E9... 19/6/2024 | 4:25:53 PM BRT

LEONARDO KÖPPE MALANSKI

SOCIAL TRANSMISSION BIAS:

AN EXPERIMENTAL STUDY THROUGH THE WISDOM OF THE MINORITY

Thesis presented to the Postgraduate Program in Administration of Pontifical Catholic University of Paraná, as a requirement for the degree of Doctor of Philosophy in Business Administration.

APPROVAL SHEET

EXAMINING COMMITTEE

DocuSigned by:
Angela Cristiane Santos Povoa
13D260AEA0244A2... 19/6/2024 | 12:39:29 PM PDT

Angela Cristiane dos Santos Póvoa, Ph.D.

Pontifical Catholic University of Paraná

DocuSigned by:
Wesley Pech
0B2E82B27E48497... 19/6/2024 | 4:31:52 PM BRT

Wesley Pech, Ph.D

Seton Hall University

DocuSigned by:
Pedro Guilherme Ribeiro Piccoli
23E630045748443... 19/6/2024 | 5:11:34 PM BRT

Pedro Guilherme Ribeiro Piccoli, Ph.D.

Pontifical Catholic University of Paraná

DocuSigned by:
B8C979B99E5B4E5... 19/6/2024 | 9:33:03 PM BRT

Newton Carneiro Affonso da Costa Jr., Ph.D

Pontifical Catholic University of Paraná

DocuSigned by:
Justin Lee
84623DCC0D474EE... 20/6/2024 | 8:44:10 AM BRT

Joohun Lee, Ph.D

Tennessee Tech University

CURITIBA

2024

ACKNOWLEDGMENTS

Finishing this doctoral journey has been a remarkable endeavor, filled with challenges, doubts, interrogations and countless moments of growth. I am grateful for many people who have contributed to this achievement.

I would like to thank my parents for supporting my studies. I know they spared no effort to guide me on the best possible path. This accomplishment is a reflection of your belief in me.

I would like to thank my sister, my adventure and life partner, for her constant encouragement, regular humorous distractions, and willingness to help me with any problem. As simple as it seemed. Your unwavering support has brought us closer every day.

I would like to thank my advisor, Professor Angela Póvoa, for your knowledge, motivation, insights, patience and empathy, which helped me build and finish this academic crusade. I'm also glad for your support and encouragement for me to pursue my Master's and Doctorate. If I'm here today it is because your incentive since my graduation ceremony.

I would like to thank my co-advisor, Professor Wesley Pech, for his remarkable ideas, patience, methodological carefulness and "out of the box" insights. I am indebted to you for your time spent in our many, many, many meetings.

I would like a special thanks to Professor Newton Carneiro Afonso da Costa Jr. for your initial insights and for introducing me to the main topic researched on this academic journey: social economics and finance.

I would like to thank PUCPR for its financial scholarship, the PPAD graduate program, and its professors for what they have taught me throughout these years, transmitting knowledge and opportunities. A special highlight for professors Pedro Piccoli, Alceu Souza and Eduardo Damião.

I would like to thank Professor Stefan Palan, from University of Graz, who even physically far away, taught me how to code and properly use the *z-Tree* software and helped me debugging the code and deciphering the software's manual. It wasn't easy but we managed to accomplish it.

Finally, I would like to thank all my friends who followed either physically or emotionally present this scholarly journey, educational voyage, intellectual expedition, and learning adventure, that is, throughout this academic odyssey. You sure have contributed to this accomplishment.

Learning is the only thing the mind
never exhausts, never fears, and never regrets.

(Leonardo Da Vinci, 15th century)

ABSTRACT

This study discusses social finance, a field of finance that seeks to understand how social interactions and cultural factors influence financial behavior and market outcomes. The goal of this study was to understand the extent to which the decision-making process of following the minority can be systematically influenced. It analyzed the emergence of social transmission bias through the wisdom of minorities and looked for behavior patterns in bounded rationality decision-making. Rationality experiments were conducted on computers to see if subjects were able to understand that following the minority in some circumstances was the best strategy. Eleven logistic regression models were employed to analyze the data. Findings revealed that cognitive reflection ability, measured by CRT scores, significantly predicts rational decision-making, with higher scores linked to greater odds of rational choices. A moderation relationship was found between the majority's unanimity, the kind of signal, and the likelihood of following the best response. Whether unanimous or not, the nature of the majority significantly impacts decision-making, with non-unanimous scenarios reducing the probability of rational decisions. If there was a deviator from the unanimous majority, players sometimes changed their course of action and, therefore, their likelihood of choosing the best response alternative. It aligns with pillars of social transmission bias since subjects followed the minority as they had an attraction for a particular option, but there was not necessarily a preference for it. It was seen that players developed a systematical behavior when deviated from the rational choice, becoming majority avoiders. Subjects with higher cognitive ability had lower chances of following the information cascade because they could have higher numeracy skills and, therefore, chose the best response alternative more frequently. Therefore, this data and results corroborate the statement that economic agents incur in the transmission of information, and as they pass on information from one individual to another, they systematically modify their decision-making, seeking to maximize their utility with bounded rationality levels, disregarding their private information.

Keywords: social transmission bias; cognitive ability; informational cascade; experiments; Minority.

RESUMO

Esse trabalho discorre sobre a "*social finance*", campo das finanças que procura entender como as interações sociais e os fatores culturais influenciam o comportamento financeiro e os resultados do mercado. O objetivo deste estudo foi compreender em que medida o processo de tomada de decisão de seguir a minoria pode ser sistematicamente influenciado. Analisou-se o surgimento do viés de transmissão social através da sabedoria das minorias e procurou padrões de comportamento na tomada de decisões de racionalidade limitada. Experimentos de racionalidade foram realizados em computadores para ver se os participantes eram capazes de compreender que seguir a minoria em algumas circunstâncias era a melhor estratégia. Onze modelos de regressão logística foram estimados para análise dos dados. Os resultados revelaram que a capacidade de reflexão cognitiva, medida pelas pontuações do CRT, prevê significativamente a tomada de decisões racionais, com pontuações mais altas associadas à maiores probabilidades de escolhas racionais. Se houvesse um desvio da maioria unânime, os jogadores algumas vezes mudavam o seu curso de ação e, portanto, a sua probabilidade de escolher a melhor alternativa de resposta. Resultados se alinham com os pilares do viés de transmissão social, uma vez que os sujeitos seguiam a minoria possuíam uma atração por uma determinada opção, mas não havia necessariamente preferência por ela. Observou-se que os jogadores desenvolveram um comportamento sistemático quando se desviaram da escolha racional, evitando a maioria. Participantes com maior capacidade cognitiva tiveram menores chances de seguir a cascata de informações porque podem ter maiores habilidades numéricas e, portanto, escolheram com mais frequência a melhor alternativa de resposta. Portanto, os dados e resultados corroboram a afirmação de que os agentes econômicos incorrem na transmissão de informações e, ao repassarem informações de um indivíduo para outro, modificam sistematicamente sua tomada de decisão, buscando maximizar sua utilidade com níveis de racionalidade limitados, desconsiderando suas informações privadas.

Palavras-chave: viés de transmissão social; capacidade cognitiva; cascata de informações; experimentos; minoria.

RESUMEN

Este estudio trata sobre la "*social finance*", un campo de las finanzas que busca comprender cómo las interacciones sociales y los factores culturales influyen en el comportamiento financiero y los resultados del mercado. El objetivo de este estudio fue comprender hasta qué medida el proceso de toma de decisiones de seguir a la minoría puede influirse sistemáticamente. Analizó el surgimiento de sesgos de transmisión social a través de la sabiduría de las minorías y buscó patrones de comportamiento en la toma de decisiones con racionalidad limitada. Se realizaron experimentos de racionalidad en computadoras para ver si los participantes eran capaces de comprender que seguir a la minoría en algunas circunstancias era la mejor estrategia. Se estimaron once modelos de regresión logística para el análisis de datos. Los resultados revelaron que la capacidad de reflexión cognitiva, medida por las puntuaciones del CRT, predice significativamente la toma de decisiones racionales, y las puntuaciones más altas se asocian con mayores probabilidades de elecciones racionales. Si había una desviación de la mayoría unánime, los jugadores algunas veces cambiaban su curso de acción y, por lo tanto, su probabilidad de elegir la mejor alternativa de respuesta. Los resultados se alinean con los pilares del sesgo de transmisión social, ya que los sujetos que seguían a la minoría se sentían atraídos por una determinada opción, pero no necesariamente tenían preferencia por ella. Se observó que los jugadores desarrollaron un comportamiento sistemático cuando se desviaron de la elección racional, evitando a la mayoría. Los participantes con mayor capacidad cognitiva tenían menos probabilidades de seguir la cascada de información porque pueden tener mayores habilidades numéricas y, por lo tanto, eligieron la mejor respuesta alternativa con mayor frecuencia. Luego, los datos y resultados corroboran la afirmación de que los agentes económicos incurren en la transmisión de información y, al pasar información de un individuo a otro, modifican sistemáticamente su toma de decisiones, buscando maximizar su utilidad con niveles limitados de racionalidad, ignorando su información privada.

Palabras-llave: sesgo de transmisión social; capacidad cognitiva; cascada de informaciones; experimentos; minoría.

LIST OF ABBREVIATIONS AND ACRONYMS

BF	Behavioral finance
MFT	Modern Finance Theory
UMS	Unanimous majority scenario
CD	Constitutive definition
CRT	Cognitive reflection test
Non-UMS	Non-unanimous majority scenario
OD	Operational definition
SET	Self-enhancing transmission bias
WOM	Word-of-mouth

LIST OF FIGURES

LIST OF TABLES

TABLE OF CONTENTS

1 INTRODUCTION

Regarding Behavioral Finance, it is understood that it should not be seen as an opponent of Modern Finance Theory (MFT) but rather as an improvement of its original models (Anache, 2008). In addition, it is established that the current sophisticated mathematical models are not useless; they need to be improved even more, combining studies on investor irrationality (Anache, 2008, p. 132).

As much as the paradigm of rational expectations is still predominant in finance research, there is a growth in the use of non-traditional finance methods, theories, and concepts, which show new ways of building knowledge in extraordinary science. “Cross-disciplinary research will challenge future finance scholars to become familiar with ways of seeing the world and doing research currently applied in other disciplines” (Gippel, 2013, p. 142).

As a scientific field, it is understood that finance researchers and scientists must accept challenges where the area itself will evaluate the research agenda. “Without discourse and debate to open our perceptions to other ways of seeing and doing, changing our view of the world and maintaining relevance in a rapidly changing world will be difficult indeed.” (Gippel, 2013, p. 142). Anyway, it is understood that whatever scenarios result from the maintenance of the current paradigm in finance or even the genesis of a new paradigm in the future, the study of finance would be helpful.

In the discussion of the MFT paradigm, the study of social finance and economics appears as a field of finance where one seeks to understand the cultural evolution of investors’ financial traits. These biases can shape this process and the resulting market dynamics. To this end, it uses concepts from MFT, behavioral finance, the theory of cultural evolution, and evolutionary finance (Hirshleifer, 2020a). Thus, it seeks to combine agent-based modeling of transmission biases with agents’ beliefs and asset choices. The main goal of this theoretical framework is to understand how social interaction affects economic results. To reflect how information and investor sentiment are transmitted, thought and behavior “contagion” must be added to the MFT (Hirshleifer & Teoh, 2009).

As Bikhchandani et al. (2021) state, agents continue evolving and learning from society, given that others may hold different, confidential, important information, etc. Because of social learning, it is observed that there is a convergence in behavior, as some individuals watch other people’s decisions and try to repeat them.

Han et al. (2022) admit that social interactions affect the way of thinking and attitudes of managers and individuals when operating in the financial market. Therefore, it is seen that social finance seeks to integrate this process in which ideas are transmitted, affecting negotiation strategies. In an increasingly connected society, which interacts in distinct ways (online forums, lectures, text messages, brokerage intranet, etc.), a "social emergence" arises as an indirect effect (Hirshleifer, 2020a, p. 1780) where social results are not defined only by the sum of individual propensities. Such a reality may appear, e.g., when there is an attraction, but there is not necessarily a preference for a particular asset, behavior, or strategy. Hirshleifer e Teoh (2009) acknowledge that economic agents are repeatedly influenced, and what can change is the channel of influence. It can act through rational learning or irrational mechanisms, such as emotional responses to conflicting decision-making situations.

In this new theoretical framework, as well as in behavioral economics, it is essential to consider investors' psychological biases. Therefore, using assumptions derived from available evidence, we seek to understand not only the direct effects that have already been studied but also the effects that are socially emerging on economic behavior in a systematic way (Hirshleifer, 2020a).

Knowing the behavior of social networks and their respective patterns of interaction originates from the perception that the social context is an essential and deterministic variable in the conduct of economic agents. I.e., comprehending the impact of networks on information flow is necessary to understand some aspects of the market, which involve networks of agents negotiating with another agent and transmitting potential information (Jackson, 2009, pp. 489–490).

Thus, it is intended to address this framework: the interaction between connected investors who interact with each other, but also consider the existence of intrinsic factors to the individual, such as psychological biases. This study becomes relevant for understanding the different settings in financial choices, given that there are different realities for different social groups with different individual axioms of preferences. However, they can still think and act similarly, converging in a similar result, providing a social emergence.

1.1 PROBLEM STATEMENT

Considering the interrelationship between market agents and investors' performance, as well as their insertion in a social context, bounded rationality with different emergences of biases, with the lack of an approach in the literature on the theme proposed here, this research problem is: Do subjects realize when their best course of action is to follow the minority?

1.2 RESEARCH OBJECTIVES

1.2.1 Research goal

The purpose of this study was to understand the extent to which the decision-making process of following the minority can be systematically influenced.

1.2.2 Research objectives

To achieve the research goal, it was empirically checked subjects' bounded rationality and how the emergence of biases may arise due to social transmission. Therefore, the proposed specific objectives are listed below:

a) Analyze the emergence of social transmission bias through the wisdom of minorities.
b) Find patterns in bounded rationality decision-making.
c) Analyze the emergence of social transmission bias through information cascades.
d) Analyze the relationship between cognitive skills and bounded rationality.

2 THEORETICAL FRAMEWORK

2.1 MODERN FINANCE THEORY AND BEHAVIORAL FINANCE

Given the methodology proposed by Kuhn (2017), it is understood that the structure of Modern Finance Theory has been questioned regarding certain established assumptions, whereas Behavioral Finance has emerged with new conceptual structures that could generate a new paradigm. It is stated that the first theory does not explain some problems, and in the finance context, they may contribute to anomalies emergence.

According to Kuhn's ideas (2017), science has some key concepts, such as the paradigm, normal science, the period of model crisis, and the period of model revolution. Kuhn did not seek to create timeless rules to characterize science but tried to understand scientific activity by focusing on the history of this discipline. Following his logic of thought, science is conceptualized as a remarkably successful undertaking and, therefore, one of the best products of the reason for overcoming obstacles imposed on the human species by nature (Mendonça & Videira, 2007, p. 169).

According to Anache and Laurencel (2013), the Modern Finance Theory is based on the Efficient-market hypothesis (EMH), which originated from the premises of neoclassical economics, founded on *Homo economicus*. Among its principles, it establishes that the investor seeks to maximize his utility based on an ordered preference. The rational decision criterion between assets consists of the fundamental value of the asset: the present value of generated cash flows discounting its risk (Shleifer, 2004). Therefore, investors optimize their individual well-being. Still, the EMH postulates that investors fully exploit arbitrage opportunities and that agents make decisions endowed with unlimited rationality.

Then, the field of Behavioral Finance (BF) appears, which seeks to fulfill insufficiencies that MFT does not explain as a counterpoint to the unlimited rationality postulated by the theory. An example would be the EMH's fragility since there are limits to arbitrage, given that several agents' wrong decisions do not necessarily create risk-free arbitration opportunities for other agents (Anache & Laurencel, 2013, p. 89).

As Simon (1955, p. 114) said, the human being ceases to be an economic individual and becomes an "organism endowed with limited skills and knowledge." Based on these new attributes, an attempt is made to explain the differences between the simplified models and actual reality. Such distinctions then manage to explain the phenomena of organizational behavior.

Thus, the BF theoretical framework arises intending to lessen some assumptions of neoclassical theory. It analyzes investors' rationality, cognitive processes, and influence on decision-making, mainly in transactions and investment choices in the capital market (Fromlet, 2001).

According to Kuhn (2017), paradigm rupture involves changing a complete structural model. The new paradigm "resets" the previous paradigm, changing the entire scientific model that was previously effective. I.e., a new paradigm emerges to supplant the old one. Soon, it becomes the prevailing paradigm, as two paradigms cannot coexist concomitantly. The philosopher points out that to reject a paradigm without simultaneously replacing it with another is to reject science itself (Kuhn, 2017, p. 109).

Among the basic assumptions of market efficiency, it is admitted that the investor uninterruptedly seeks to maximize the expected utility based on his axioms of preference. Also, it is established that the agent makes completely unbiased predictions about the future. However, these views can be somewhat extreme, not reflecting human and market reality (Burton & Shah, 2013; Thaler, 1999, p. 12).

Another argument occurs regarding the investor's character. Given that the market is made up of human beings, it is susceptible to errors, Thaler (1999) argues that the market can be made up of rational investors (precisely as predicted by classical economic theory) and also made up of "quasi-rational" investors, those who try to operate strictly rationally, but make predictable mistakes. Shleifer (2004) admits that irrational individuals are participants in the market, however, their movements cancel each other out. Nevertheless, their operations can also be smoothed out by rational arbitrageurs.

So, it is noted that the rationality theory cannot explain why a good is preferred over another or why such a good satisfies a given preference. This is because it does not consider feelings, emotions, or moods. The principle of the utility function explains the preference relationship. Such comparison is given by establishing a specific value for each alternative, where the number follows the respective line of preference. In other words, "utility is nothing more than an index or measure of preference" (Angner, 2012, p. 12).

Kahneman e Tversky (1979) acknowledge the existence of human behaviors that violate the consistency and coherence principles, as they differ from the standard rational decision of the expected utility theory since they do not respect the axioms of invariance and transitivity. For the theoretical framework of Behavioral Finance, expectations are not exclusively homogeneous and are susceptible to changes between individuals or over time.

Thus, research in finance admits a more heterogeneous character than before the rise of BF. Although the final result may involve a modification of the current paradigm rather than changing its wholeness, it can be assumed that the study of finance is currently in a period of extraordinary science. This is justified by the emergence of approaches that significantly changed the field's boundaries, relating finance to different fields (such as psychology, sociology, neuroscience, biology, etc.). With these new approaches, the fundamental assumption of human rationality is questioned, moving the field of finance outside the comfort zone of modeling and empirical testing and incorporating methods and theories from other disciplines (Gippel, 2013, pp. 128–129). As previously mentioned, the approach seeks to understand the rational or irrational behavior of agents and has required new methodologies that were not addressed in MFT so far, such as laboratory experiments and surveys.

Then, it is understood that the research moves toward the possibility of a new research paradigm, providing constructive criticism for the appearance of innovations in concepts and methodologies, enabling the constitution of the new paradigm. For Anache (2008), adding new content characterizes a scientific advance in Lakatos' understanding and makes BF an alternative to MFT. Still, it is admitted that "the protective belt of [...] [MFT] has been showing a certain fraying, which, according to the Kuhnian proposal, causes a weakening of the current paradigm, with the appearance of recurrent anomalies and unexplained" (Anache, 2008, p. 17).

From the point of view of Lakatos (1979), it is understood that BF weakens the protective belt around the MFT since its auxiliary hypotheses, such as the agent's rationality, have been questioned. The philosopher states that scientific revolutions do not occur immediately. The Adaptive Markets Hypothesis (AMH) developed by Lo (2005) tries to merge BF with the original premises of the MFT.

According to the HMA, events cause psychological alterations in the agents, which incorporate information into prices differently. Consequently, temporal variations may arise in the serial correlation of returns (Kim, Lim, Shamsuddin, 2011 as stated by Dourado & Tabak, 2013). It is admitted that given the continuous market evolution, its agents act rationally since they have a great knowledge of the events that occurred as well as of the current economic model. However, when there are market anomalies or disturbances, these same agents abdicate rational analysis and replace it with instinctive behavior (Lo, 2005; Mayer, 2019). Therefore, it seems that BF emerges as a research program that challenges the MFT research program.

Still, it is observed that individual and psychological issues influence the context of economic decisions and the individual's relationship with other members of society. Therefore, in the context of society and relationships in networks, the following subsection details this meaningful relationship that must be inserted into the theoretical and methodological framework.

2.2 SOCIAL ECONOMICS AND FINANCE

Social economics and finance seek to expand the “intellectual toolkit” and aim to understand the preferences, psychological biases, optimization, and balance of agents in the market. Additionally, behavioral economics bases assumptions on available psychological evidence and the theory of evolutionary culture and evolutionary finance. So, it is assumed that this theoretical approach seeks to understand the socially emerging effects that occur systematically (Hirshleifer, 2020b). This new thinking archetype implies that specific cases and particular characteristics, considered pre-established in traditional models, are now endogenized to the model. Also, in this approach, economic agents and investors acquire characteristics that look for trends or divergent traits of other people in a cultural transmission process (Akçay & Hirshleifer, 2021).

The main research effort of social finance is on the cultural evolution of financial characteristics, the biases that model these processes, and, consequently, the dynamics of the market in which agents are inserted. There is evidence that naive thoughts and folk models are culturally transmitted between investors and agents, thus influencing negotiations and asset prices. This set of information arises from the assumption that managers and investors have about the functioning of the economy and the market behavior and pass it forward. Therefore, it is called “social transmission,” the carrying of ideas or signals between one individual and another. With this dissemination, it is assumed that financial traits are broadcasted, and their distribution within the population evolves over time (Akçay & Hirshleifer, 2021).

Furthermore, in social finance research, not only is the evolution of investor wealth taken into consideration, but also the evolution of the distribution of characteristics among these investors within a society. These characteristics are assumed to be subject to change traits such as the propensity to save, beliefs in investor philosophies or negotiation, and investment strategies. One of the main attentions of the social finance approach is the social transmission bias, in which it is assumed that economic agents observe and interact with each other (physically or through social networks), leading to a systematic directional modification of ideas or signals as they pass from one agent to another economic agent.
(Hirshleifer, 2020b, p. 10).

For (Hirshleifer, 2020b), social transmission bias refers to the fact that signals and ideas are systematically modified in their transfer from a sender to a receiver. Therefore, social transmission bias results from a combination of sender bias (in the information that is sent) and receiver bias (in the information that is observed and understood). A primary implication of social learning is that people who observe others' choices often begin to behave in similar ways (Bikhchandani et al., 2021). One of the differences between social transmission bias and herd behavior is that social emergence arises when subjects can be attracted to a behavior, an option, or an alternative without any preference for it. Also, there are direct and indirect effects, such as when an indirect effect is a social emergence: "when the phenomenon that aggregates social outcomes are not just the sums of individual propensities." (Hirshleifer, 2020c, pp. 4–5)

According to Hirshleifer and Teoh (2009), some investment theories have more robust dissemination and survival due to their properties that make them better at replication (more contagious or persistent). The authors admit that rational observational learning shows that some seemingly irrational events can arise naturally in entirely rational environments. It can be exemplified as:

a) Frequent convergence of individuals in mistaken assets, based on little investigation and little information;
b) The fragility of social outcomes concerning small shocks;
c) Individuals tend to delay decisions for long periods and then suddenly act simultaneously without a substantial external trigger.

Regarding the sources of behavioral convergence, it is necessary to consider the agents' feelings and actions, which are influenced by verbal communication or even observation of actions. According to (Bikhchandani et al., 2021), social learning can provide two distinct patterns: the convergence of agents based on the same action, generating low payoffs; or contingent outcomes (path-dependent), where they are fragile and sensitive to informational shocks (such as the effects of unemployment crises, medical practices, and treatments, etc.).

When agents are concerned about their reputation, a phenomenon known as information cascade may arise. They can easily occur as an agent seeks to build a reputation as a good decision-maker based on information from previous (Ottaviani & Sørensen, 2000, as cited by Hirshleifer & Teoh, 2009, p. 7).

Rational learning through information in a "cascade" may be observed within the social transmission bias. It is understood that this phenomenon can block information, reducing the quality of decisions taken *a posteriori*. Informational cascades can happen in different shapes and configurations, such as a new medical treatment, the adoption of new technologies, and responses to environmental damage, among others. However, the best-known ones happen in the financial market, where the appearance of market bubbles and stock drops could be good examples (Alevy et al., 2007). Some economic agents may, following other agents, incorrectly infer that this negotiation results from non-existent privileged information and even feedback this cycle by attracting new investors (Anderson & Holt, 1997).

Informational cascades happen when there is a situation where the individual acts independently of the signals of his private information. In the model proposed by Bikhchandani et al. (1992), a specific sequence of individuals (or economic agents) are proposed ex-ante identical alternatives, such as an investment project. The individual can visualize the actions but not the profit of his predecessors. The first individual, stated as i, is in an informational cascade, and the following agents are aware of this situation. Therefore, agent $i + 1$, is the next one, but without learning anything from agent i, is in the same choice position as agent i, resulting in the choice of agent $i + 1$ being equal to the choice of agent i, regardless of the private information of agent $i + 1$. Thus, following an inductive hypothesis, all other agents follow the same line of thought up to agent $i + n$.

Figure 1 exemplifies the event of the informational cascade: where strategies h or l can be chosen and later represented by two states, respectively, by H and L. If agent I_1 chooses strategy h, then agent I_2, if in a cascade, can understand that agent I_1 has some information and follows the same behavior: choose h. Alternatively, he can ignore the information and opt for his private information, i.e., no cascade. In that case, he might assign a probability $p = 0.50$ to choose h and a probability $q = 0.50$ to choose l.

Next, agent I_3 can find itself in three different scenarios: (1) when I_1 and I_2 choose the same strategy h h; (2) when I_1 and $I2$ adopt the same strategy l l; or (3) when I_1 and I_2 adopt different strategies: h l or l h. In situation (1), agent I_3 chooses the same strategy h, even though he knows the probabilities p and q are established by agent I_2. In situation (2), the same thing happens as in situation (1), however with strategy l. Therefore, I_3 chooses strategy l. In situation (3), agent I_3's decision problem becomes the same as agent I_1's decision problem, based only on its private information signal.

Successively, agent I_4 finds itself in the same position as agent I_2, needing to consider its predecessor agent. Thus, it can be admitted that the "optimal decision rule" for a given agent I_n, depends on the history of action through d_n, defined as the difference between the number of previous agents that chose strategy h and the number of agents that chose strategy l. So, in that way:

a) if $d_n \geq 2$, the agent is in the informational cascade and chooses the strategy regardless of its private signal;

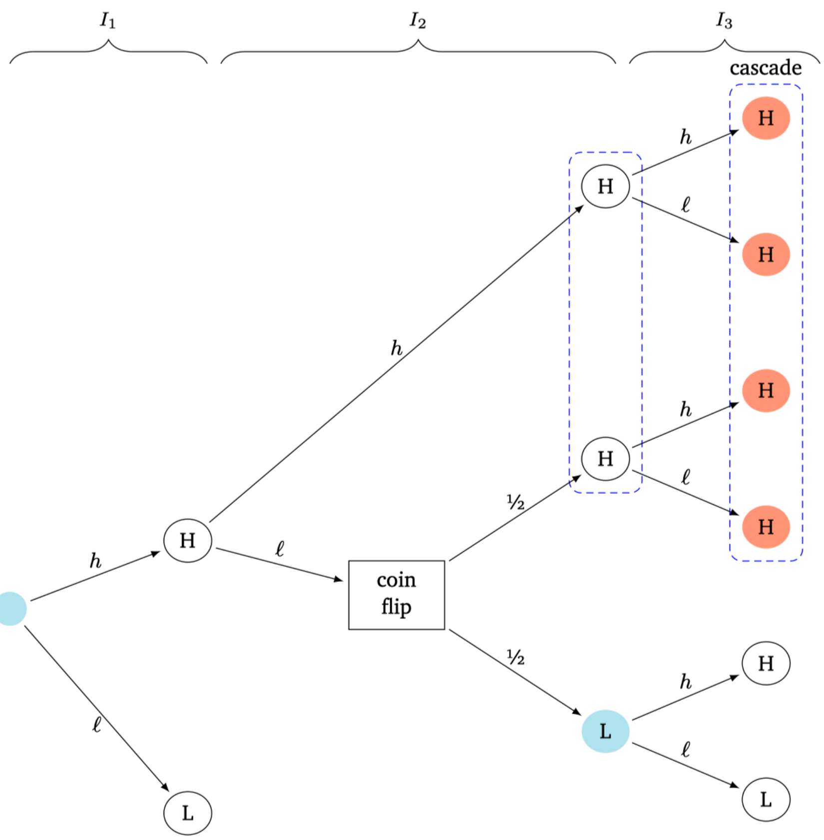
b) if $d_n = 1$, the agent follows strategy *h* if its private signal is *h* and assigns probabilities *p* and *q* if its private signal is *l*;

c) if $d_n = -1$, the agent follows strategy *l* if its private signal is *l* and assigns probabilities *p* and *q* if its private signal is *h*;

d) if $d_n \leq -2$, the agent is not in the informational cascade;

e) if $d_n = 0$, the agent must choose its private information signal.

Figure 1 – Agent's informational cascade



Font: (Bikhchandani et al., 2021, p. 7)

The information becomes public, and each agent in the sequence accesses an "information pool" where he can see all the actions previously taken, reinforcing the previously observed behavior. It can be said that information cascades result from the individual's private signal being overwhelmed by the growing public pool of information (named "pool").

In the model developed by Bikhchandani et al. (1992), it is established that the economic agent, at the moment of the decision, can attribute a probability *p* to the choice of a strategy similar to its predecessors (where the agent does not give relevance to its individual signal) and a probability *1 – p* for choosing a different strategy from its predecessors (where the agent gives relevance to its individual signal), for the different scenarios adopted by its predecessors (V). Thus, the range of alternatives is given by: (h | V) or (l | V). Therefore:

Table 1 – Probabilities description

	Individual's choice	
Predecessor's choice	$\Pr(X_i = h \mid V)$	$\Pr(X_i = l \mid V)$
$V = H$	p	$1 - p$
$V = L$	$1 - p$	p

Consequently, by derivation, it is possible to find the following probabilities after two agents, as shown below: the probability of the correct cascade, the likelihood of not forming a cascade, and the probability of creating an incorrect cascade.

$$\frac{1-p-p^2}{2}, p - p^2, \frac{1-p-p^2}{2} \tag{1}$$

Accordingly, for an even number of decision-makers, we have that:

$$\frac{1-(p-p^2)^{n/2}}{2}, (p - p^2)^{n/2}, \frac{1-(p-p^2)^{n/2}}{2} \tag{2}$$

Therefore, it is observed that the closer the probability p is to 0.50, the longer the information cascade will take to start. At probability p = 0.50, the private signal carries no information. Furthermore, cascades tend to start earlier when agents have more precise private signals. Another phenomenon this model highlights is that the probability of not being part of an information cascade decreases exponentially as the number of agents involved rises.

Nonetheless, agents with different preferences can stop this phenomenon: a small disclosure of public information can change a well-established and conventional pattern of behavior, breaking the information cascade (Hirshleifer & Teoh, 2009, p. 9).

When in a cascade position, i.e., the individual's information is not relevant for the next agent to make a decision, it is assumed that social learning is blocked. So, it is understood that this phenomenon generates an information externality. If this information is unified, the overall payoff of the decision tends to be low, as these decisions are often incorrect (Bikhchandani et al., 2021).

Although there are high chances of the emergence of information cascades, they can be incorrect, given that they can be based only on information from two people, for example.

Hence, they tend to be fragile, which can quickly stop the phenomenon. According to Welch (1992 as cited by Bikhchandani et al., 1992), cascades tend to prove wrong in the long run, as they "are based on the idea that many observations of informative actions would lead with high probability to an almost perfect knowledge." Thus, with high probability, a cascade must start at or before such a point, but this cascade will usually be incorrect and will arise much earlier (Bikhchandani et al., 1992, p. 1001).

Public information disclosure can be a factor that stops (or even reverses) the information cascade (Bikhchandani et al., 1992), as it can both provide direct information to the individual and can also change the opinion of previous agents, thereby altering the information conveyed by their decisions. Although public information is sometimes "noisy," i.e., loaded with a certain amount of noise, it reduces the information transmitted to the second agent by the first agent's decision so much that it ends up overcoming the direct positive effect. According to the authors, cascades' fragility appears systematically because they provide precarious equilibriums.

In the model proposed by Bikhchandani et al. (1992), even admitting that information cascades are relatively fragile, the authors discuss society's chances of establishing itself in the "correct cascade" as more and more information is disclosed to the public. Through the law of large numbers, because cascades start based on a small amount of initial information, with more public information disclosed, the clearer the correct choice becomes. The law of large numbers "ensures that as long as public information is conditionally independent and identically distributed, the posterior concentrates on the true value, and each individual almost surely decides correctly. Thus, each individual acts like the previous individual, and the correct cascade results" (Bikhchandani et al., 2021, p. 1007).

Therefore, it is understood that social finance is characterized as an advance in the MFT, especially regarding the capital market. Its main particularities: the endogenization of previously established characteristics; the consideration of a broader universe of strategies and beliefs of investors and economic agents; the evolution of individual investor characteristics (and not just the evolution of their wealth over time); recognition of the meticulous analysis that investors carry out on the alternatives that affect the market, however imperfect they may be; consideration of social transmission bias and broader time ranges (Hirshleifer & Teoh, 2009).

Lakatos (1979) established that a research program has an irreducible core (also called hard core), in which the general hypothesis provides the basis for the development of the program itself. Around this irreducible nucleus, there is a "protective belt," which is made by the hypotheses that support the nucleus. They aim to protect the irreducible nucleus from modifications. It can be said that they are assumptions related to the primitive conditions of theory development.

The author admits that a theory should not be discarded when a single event contradicts it. Thus, he explains that a theory should only be eliminated when a better theory than the current one appears, explaining both what the current theory explains and also expanding new concepts and previously unaddressed knowledge. I.e., a theory will only be accepted as scientific if it provides empirical content corroborated in excess when compared with the predecessor or rival theory (Lakatos, 1979 as cited by Silva & Costa, 2019, p. 7).

Hence, it is essential to emphasize that the discussion around social finance vs. BF is at a previous step compared to the discussion of MFT *vs*. BF. While BF revises the traditional MFT paradigm, social finance still corroborates assumptions established by the BF paradigm.

Social finance discusses the "protective belt" that exists over the hard core of Behavioral Finance, as explained by (Lakatos, 1979). Such analysis arises precisely because social finance seeks to expand the "intellectual toolkit" of BF. As mentioned earlier, it seeks to base assumptions both on available psychological evidence and on the theory of evolutionary culture and finance evolutionary traits (Hirshleifer, 2020b).

From the concept of social transmission bias, there are mechanisms through which information is sent and transmitted to other economic agents. The emergence of the information cascade has in its model factors that combine the external information received by the agent, but it can also be visualized through other structures. Self-enhancing bias and folk model bias are examples of mechanisms that can nurture social transmission bias. The following subsections detail these topics to elucidate the constructs better.

2.2.1 Self-enhancing transmission bias

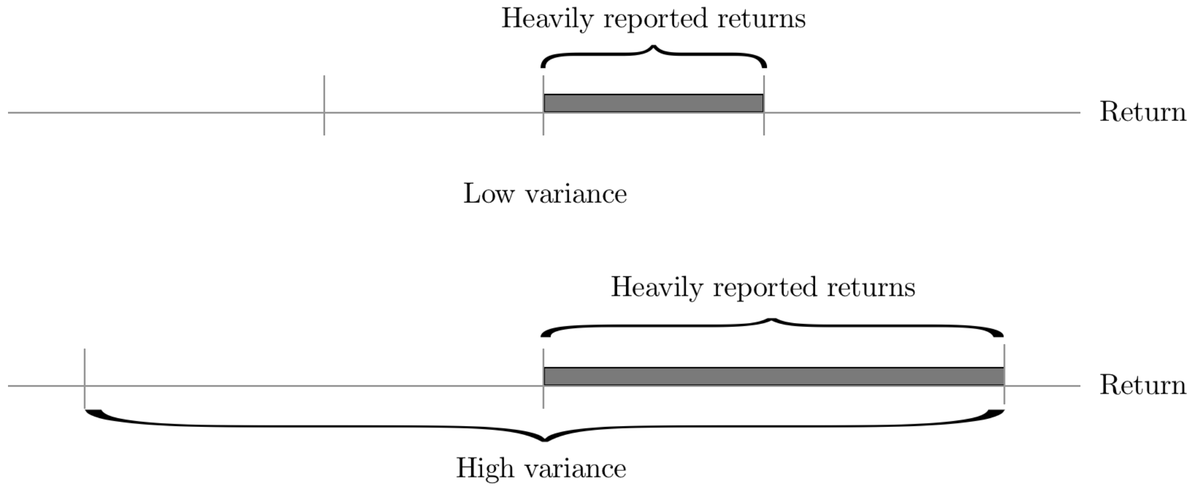
As Han et al. (2018, p. 1) proposed, in the financial market, "in most investment models, the influence of individual choices on others is mediated by the price or quantities traded in impersonal markets. However, more direct forms of social interaction also affect investment decisions." Among the contexts addressed by social finance, one can highlight the self-enhancing transmission bias (SET) study proposed by the related literature (Han et al., 2022; Hirshleifer, 2020a). The assumption behind bias modeling is that investors are attracted to assets with high volatility (variance) and asymmetry, however, these agents do not necessarily have a preference for this type of asset. Some authors have found evidence that individual investors have a preference for stocks known as “lottery stocks” (stocks with high asymmetry).

Kumar (2009, p. 1930) shows evidence that individual investors invest “disproportionately more” in stocks with lotteries’ attributes and that there is an inverse relationship between socioeconomic status and the demand for these types of assets. This disproportionate investment results in lower portfolio performance, as evidenced by lottery studies.

When analyzing the stock’s asymmetry, given that portfolio diversification can reduce the degree of asymmetry, Boyer et al. (2010, p. 171) admit that there are certain investors who, due to their attraction to idiosyncratic volatility, may accept lower average returns because they have a preference for stocks with return properties similar to lottery stocks and not because they seek greater volatility. The authors conclude that predicted asymmetry justifies the relationship between volatility and expected returns on an asset and that despite market imperfections, such as information asymmetry, and that the negative relationship between idiosyncratic volatility and expected returns lies in the investor preferences.

The model proposed by Han et al. (2022) and also by (Hirshleifer, 2020a) admits that an investor can adopt an “Active Investment Strategy” (A) or a “Passive Investment Strategy” (B), where option A is riskier, both being measured by its volatility and asymmetry. In the SET bias, economic agents end up transmitting, among themselves, information that promotes strategy A more than strategy B. When agents announce and disclose, in an uneven manner, their victories and profits in the market, more than their losses, it is assumed that this investor incurs in the SET bias. In this way, more investors receiving the message will listen to strategy A because, in general, it can present higher returns than strategy B, but not always. Still, the possibility of spreading high volatility strategies increases as investors worry about the extremes (highest returns). Therefore, it is assumed that strategies with more significant asymmetry tend to spread more quickly, as agents are more likely to disclose their gains than their losses. I.e., positive WOM (word-of-mouth) in these agents tends to predominate and spread more quickly than negative WOM (East et al., 2007 apud Han et al., 2022; Hirshleifer, 2020a). This phenomenon is illustrated in Figure 2:

Figure 2 – Self-enhancing transmission bias (SET)



Font: adapted from (Hirshleifer, 2020b).

On the other side, it should be taken into account that there are also factors of the message receiver that can influence the transmission of information, such as knowledge about the market or even an individual and psychological bias, such as the representativeness heuristic (where the investor emphasizes that a small sample with a good performance and return is capable, excessively extrapolating these returns to other assets, population, etc.), in addition to the SET bias of the message sender. Another example of a phenomenon likely to occur in receivers is the visualization of past performance and profitability as a strong indicator of future performance (Hirshleifer, 2020a).

Nevertheless, Han et al. (2018, p. 5) admit that the effects of SET bias are more evident when the social interaction degree of intensity is higher. Thus, it is implied that there is an influence on the communication process among investors about the performance of their investment strategies. According to the authors, the evidence supports the hypothesis that these effects are associated with sociability proxies. Therefore, it is shown that an agent's strategy depends on the ties with whom the investor is connected, the performance, the volatilities and distortions of the network neighbors' strategies, and the investors' sociability. So, it is observed that the SET bias can be a mechanism that encourages the emergence of the informational cascade, which shows its inclusion within the theoretical framework of the social transmission bias, as mentioned in the previous subsection.

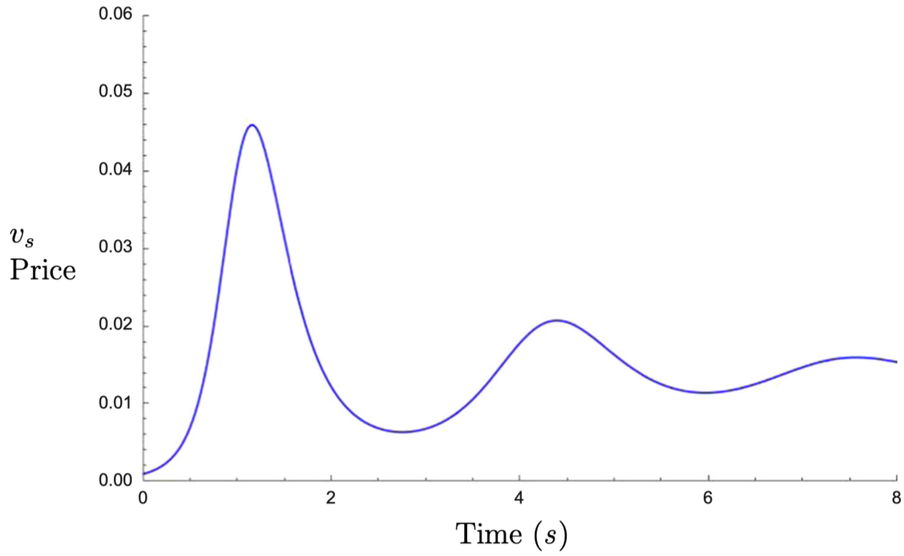
2.2.2 Biased transmission of folk models

Nevertheless, within the social transmission, the literature admits that popular models (called "folk models") are, in essence, a belief in a model of how the world works, i.e., an "internal representation of external reality" (Hirshleifer, 2020a, p. 1812). These models assume excessively simplified denotations or even emotional connotations. They are disseminated among agents and investors, from person to person, through conversations and, in a way, compete for society's attention.

The literature shows evidence that stocks buying and selling popular models, as well as bubbles in stock prices, spread similarly to the contagion mechanism (Burnside et al., 2016, Shiller, 2017, Shive, 2010 as cited by Hirshleifer, 2020a). The SIR model originated from epidemiology studies can explain this phenomenon. In this model, individuals are characterized as susceptible (S), "infected" (I), or recovered (R). In the beginning, all of them fall within group S, given a probability p of contamination, the agent can migrate to group I and then move on to group R.

The model suggested by Hirshleifer (2020b) is called SIRS and admits a group of economic agents (investors) in a stock market, where these investors and stock prices have a deterministic behavior. Within this market, investors can adopt rational beliefs, which are those contained in the S group or in the R group, and those who adopt emotional beliefs (or super optimistic), which are contained in the I group. For the author, what establishes the probability of contagion p is determined by the level of enthusiasm that a specific popular model offers to its followers, called "buzz." When this noise ceases to exist, i.e., it assumes negative values, the probability p of contagion tends to zero, which prevents the growth of group I. Figure 3 below shows the price behavior due to speculation and adherence to models that have become popular over time.

Figure 3 – Evolution of the price of an asset in the market, SIRS model



Font: (Hirshleifer, 2020a, p. 1814).

"In equilibrium, prices reflect a weighted average of the beliefs of the three investor types in the population." (Hirshleifer, 2020a, p. 1814). Therefore, in practice, the probability p of contagion is not necessarily linked exclusively to the "buzz" of the popular model but to the frequency of different types of agents and investors included in that population.

2.2.3 Majorities *vs*. minorities

As previously stated, in the previous models, in some instances, the literature admits that in situations where economic agents have imperfect information about the state of the world, when making a decision, it may be rational to ignore their private signal and follow the adopted behavior by society, which may have more information through public signs (Alevy et al., 2007) or the "information pool." As discussed earlier, it is common for information cascades to emerge in this scenario, regardless of the private information that decision-makers hold. Similarly, in the model proposed by Banerjee (1992), it is observed that following the majority can also be an optimal strategy when agents without any private signal can express the absence of information.

However, it is necessary to remember that the informational cascades, as proposed by Bikhchandani et al. (1992), although they have a significant impact on society, they have a certain fragility and can be easily reversed when new public or contrary information is revealed (Alevy et al., 2007; Bikhchandani et al., 1992, 2021).

Differently, Callander and Hörner (2009, p. 1422) realized that in certain economic situations, the logic of learning and social emergence could flow to the opposite path: instead of following most people (as seen in the model information cascade), the rational economic agent can discard his private information and follow the minority. This idea of oppositional thinking arises when the minority holds more information (or wisdom) than the majority of the population in the analysis.

As addressed in the model proposed by Bikhchandani et al. (1992), an informed agent can deviate from the majority on certain occasions. However, specificities regarding the position of this deviant agent before the group (majority or minority) are not specified. The model proposed by Callander and Hörner (2009, p. 1423) seeks to specify this particular phenomenon: in situations where the decision maker can only visualize which choice composes the majority and which alternative option composes the minority of people. According to the authors, it is favorable to follow the minority group, as conventional wisdom might follow the wrong path, which is related to the transmission bias of folk models (Hirshleifer, 2020a) discussed in the previous subsection and also related to the fragility of informational cascades (Bikhchandani et al., 1992).

In the "wisdom of minority model," it is assumed that a particular population share has private information about the best choice, decision, or alternative and that this share is relatively small concerning the total population. When deciding, each agent can only observe which choices compose the majority and the minority but do not hold the sequential information about the decision-making.

Still, the authors point out in their model that "for a minority to be wise requires that the more informed agents be sufficiently informed relative to less informed agents, and for a fraction of informed agents to be sufficiently small" (Callander & Hörner, 2009a, p. 1425).

Thus, the model proposed by the authors refers to the theoretical framework of the social transmission of economic agents but in a direction "opposing the herd" and to the informational cascades. Through the subsequent interactions of the decision-making agents, choosing to follow the minority is also viewed as a social emergence, a construct addressed in the scope of social finance research.

The model proposed by Callander and Hörner (2009a) consists in a modification of the model proposed before by Bikhchandani et al. (1992), where the agents now have different levels of information (differently informed) and agents can also see the total number of predecessors that had chosen each option, but can't see the sequence of it. The foundation of the last specification, according to the authors, is that markets' agents can only see market shares and can't see sequences.

As stated by Callander and Hörner (2009a, p. 1424), the model proposed by them has two states of the world $\{\omega_0, \omega_1) = \Omega$, and a countable and finite number of agents: $n = \{1, 2, 3,\ldots\}$, where each agent should choose between two alternatives $\delta = 0$ or 1. The payoff $u(\delta)$ for each choice is 1 when the chosen alternative matches the state of the world, that is: $u(0) = 1 \mid \omega_0)$ or $u(1) = 1 \mid \omega_1)$ and zero when it does not match the state of the world. That is: $u(0) = 0 \mid \omega_1)$ or $u(1) = 0 \mid \omega_1)$.

Agents (n) should move sequentially but do not see the sequence of previous choices. Each one of them is either informed or uninformed, where they can be (relatively) informed with probability f or (relatively) uninformed. Also, the quality of the signal or information of (relatively) informed agent is given by p_H and the (relatively) uninformed agent is given by p_L, where $½ \leq p_L \leq p_H \leq 1$ (Callander & Hörner, 2009a). In the original model proposed by (Bikhchandani et al., 1992), it was assumed that $p_L = p_H$. According to the model modified by Callander and Hörner (2009b, p. 1421), "minority wisdom arises when information is sufficiently heterogeneous and the well informed are not overly abundant, yet the conditions necessary are not overly restrictive". For larger minorities, their argument for the minority loses its strength. Also, they state "that minority wisdom always arises if the fraction of informed types is small enough […] [and] the higher is q, the more a majority can be trusted relative to one's own signal, thereby inducing herding behavior" (Callander & Hörner, 2009b, p. 1432).

2.3 COGNITIVE DISSONANCE

The traditional theory of cognitive dissonance (Festinger, 1957) states that individuals with inconsistent beliefs, or who act in conflict with their beliefs, feel the dissonance, and attempting to change this situation becomes a motivating factor for behavioral change. The feeling provided by such a phenomenon is called "psychological discomfort" (Oxoby, 2003, p. 367).

Moreover, the modern theory of cognitive dissonance admits that dissonance mainly concerns self-esteem and willingness to rationalize one's actions. Consequently, the attempt to reduce this dissonance is more prevalent when the individual conflicts with his intention to be an intelligent, good, self-sufficient person, etc. So, it is understood that those who do not resolve this internal conflict may incur self-esteem problems or lack of social acceptance (Oxoby, 2003). In practice, according to Akerlof and Dickens (1982, p. 308), "most cognitive dissonance reactions stem from peoples' view of themselves as "smart, nice people. Information that conflicts with this image tends to be ignored, rejected, or accommodated by changes in other beliefs."

As stated by Oxoby (2003, pp. 367–368), "social morality may create dissonance within individuals who break moral codes." Thus, an agent or individual may reconsider their beliefs about a given decision and what they understand as morally acceptable. So, pursuing a reduction in dissonance can provide more agents who break the moral code.

In this study, the addition of the theory of cognitive dissonance clarifies some limitations of the traditional economic model, where economic agents do not act exclusively as proposed by MFT. According to Akerlof and Dickens (1982, p. 307), it is an application of the cognitive consistency theory. The justification for its addition to the economic model is based on three propositions: (1) agents not only have preferences about the different states of the world but also about their beliefs about the state of the world; (2) individuals have certain control over their beliefs, which allows them to manipulate them, selecting sources of information that are likely to confirm them; (3) it is essential that after choices are made, these beliefs persist over time.

In the model brought by Akerlof and Dickens (1982), it is understood that cognitive dissonance has a limit to the extent to which the psychological benefit of ignoring contrary evidence outweighs the risks (or losses) of ignoring adverse information. In situations where the risks are, in the subject's view, relatively lower, the agent tends to revise his beliefs in order to adjust his current attitudes.

According to the authors, the debate occurs over the characterization that psychologists attribute to cognitive dissonance rather than "rational behavior under Bayesian decision theory." Such an analysis is justified, firstly, by the evidence that agents with cognitive dissonance reactions have later distributions that are not proven only by the information they have available but by the fact that the estimate of the state of the world is influenced by their preferences about their state of belief. The evidence of Jellison and Mills (1967 as cited by Akerlof & Dickens, 1982) shows that different groups of individuals with the same information have systematically different beliefs, which conveniently follow their order of preference.

Therefore, through Bayes' decision rules, "agents' estimates of the state of the world are only influenced by the information available to them and their preferences over states of the world, but these estimates are independent of their preferences for beliefs per se" (Akerlof & Dickens, 1982, p. 309).

Gilad et al. (1987) admit that the decision-making process admits an analysis of simplification of cognitive processes, where this process can be segmented into two categories: first, the information that is “allowed to enter” the decision-making process, and then, from the moment that this information is absorbed by the agent, what treatment and destination is intended to be given to it.

In the first moment, before introducing new information available to the agent, the authors establish three possible behavioral processes that may limit the input of information: hypothesis bias; adjustment and anchoring; and process related to escalating commitment. The first one is the situation where a prior belief about the state of the world leads to ignoring information that does not confirm it. In the second case, the initial estimates serve as an anchor, making subsequent adjustments relatively small in light of new information that requires revisions to the original estimate, which prevents the agent from fully using all available information. Finally, the third case involves “inappropriate discounting of negative information regarding a previous commitment to a course of action” (Gilad et al., 1987, p. 62).

Thus, it is understood that the cognitive dissonance theory can explain possible changes in behavior patterns where economic agents provided (or not) with psychological biases, including confirmation bias, end up changing their attitudes in the market to reduce their psychological discomfort (Oxoby, 2003) or better handling external information after “allowing it to enter [their mind]” (Gilad et al., 1987), where the ultimate goal would be to maximize the individual’s utility.

2.4 COGNITIVE REFLECTION AND DECISION MAKING

The cognitive ability level has an influence on many aspects of people’s regular lives according to (Frederick, 2005a; Jensen, 1998) , such as people’s life expectancy, income, faster reaction times, susceptibility to visual illusion, etc. The cognition process called as “System 1” processes information immediately and seamlessly and it is not influenced by intellect, awareness, drive, or the complexity of the math task being undertaken in that moment. However, the cognition process called as “System 2” demands concentration, focus and effort (Frederick, 2005a; Kahneman, 2012). Therefore, it can be said that the human mind processes information in a dual way. Cognitive reflection has been defined as both a “disposition” and an “ability” (Frederick, 2005b). The ability could be defined as the capacity to learn a new skill or task quickly.

Some studies analyze the relationship between cognitive ability and economic behavior. In the data analyzed by Frederick (2005a, p. 33), it was shown that risk-taking gains and cognitive ability were correlated not only by a greater disposition to compute expected utility. It was seen that participants of the study who showed higher cognitive abilities, when there was loss involved, this group was less risk-seeking, i.e., "they were more willing accept a sure loss to avoid playing a gamble with lower (more negative) expected value." As stated by prospect theory, people will be more willing to take risks to avoid losses than to achieve gains, the study's result showed the importance of bearing cognitive ability in mind when assessing the descriptive validity of a decision-making theory.

The cognitive reflection test appears as a methodology to assess people's behavior, as there is always an intuitive and incorrect answer (sent by System 1) and a correct one that requires a little bit more thinking (sent by System 2). The cognitive reflection ability refers to the "individual ability or disposition to stop the first impulsive response that our mind offers and to activate the reflective mechanisms that allow us to find an answer, make a decision, or carry out a specific behavior in a more thoughtful way" (Frederick, 2005a; Otero et al., 2022, p. 1).

In that way, the CRT is composed of some questions (usually three questions) that try to trigger respondents to answer immediately but incorrectly. Frederick's (2005) results showed that participants who scored more in the CRT were the ones who were more "patient". Players with higher scores in the CRT were more inclined to choose the later larger reward. Studies have been conducted and correlated CRT results with specific genitive abilities, for example, mechanical-spatial ability, numerical ability, verbal ability, perceptual speed, numeracy skills, memory capacity (Otero et al., 2022). In a similar way, the meta-analysis made by (Otero et al., 2022) found a significant positive correlation between cognitive reflection and job performance and training proficiency.

The study made by Avram (2018) comments that although there is some previous literature that established CRT scores differences between genders, suggesting that men tend to outperform women in tasks that require analytical reasoning, her data found results consistent with previous research, however, the difference was not statistically significant. Analyzing the social-demographic characteristics, she found that older participants, as well as students majoring in economics or related fields, tended to perform better on the CRT.

Campitelli and Labollita (2010) studied undergraduate students and found some correlations between the decision-making process and cognitive reflection. In their sample data, participants with higher CRT scores tended to show greater risk aversion: preferring safer assets than riskier other options. This means that those more inclined toward reflective reasoning may be more cautious when faced with uncertain outcomes. Also, they found that higher levels of cognitive reflection were associated with reduced susceptibility to framing effects. Participants with higher scores on CRT were less likely to be influenced by the way information was presented and more likely to make decisions based on the underlying content of the information.

3 THEORETICAL GAP

Bearing in mind that agents, companies, and organizations are situated in a business environment endowed with social interactions that directly and indirectly influence their performance, it is understood that better understanding such context of individual decision-making translates into benefits for the management literature.

As previously seen, current models that analyze the capital market equilibrium consider behavioral aspects but do not investigate how economic agents and investors create naive ideas and thoughts about the functioning of the capital market, nor how these analysis and points of view spread throughout society (Hirshleifer & Teoh, 2009). Therefore, it is crucial to analyze the social influence on the study of economics and finance so that social transmission can influence the capital markets theory.

According to C. W. Park et al. (1988), actual knowledge and perceived knowledge are expected to match each other during the initial stages of knowledge accumulation. However, with the advancement of knowledge that individuals have over the accumulation of information provided by various tools and information exposure (media, internet, search engines, etc.), the "phenomenon of the illusion of knowledge" is developed, whereby individuals' subjective beliefs about levels of knowledge (i.e., the depth and breadth, relevance and accuracy of knowledge) become much greater than their objective levels of knowledge.

Evidence shows that when perceived knowledge is low, economic agents have lower confidence levels about their own knowledge, which generates greater motivation to value, process, and use new information. So, these results suggest that those individuals with greater perceived knowledge may be more confident about their levels of knowledge and, therefore, less willing to value new and potentially valid and essential information. Still, it is estimated that when exposed to information that is not confirmed, these same individuals, those with greater perceived knowledge, are more likely to discount the value of such information in favor of those that confirm their feelings (C. W. Park et al., 1988).

Regarding the study of networks and economic behavior, Jackson (2009, p. 490–491) justifies that the interest in behavioral economics comes from the perception that psychological factors and the context in which the individual is inserted can influence decision-making and, consequently, economic behavior. Likewise, interest in social networks and the interaction patterns underlying economic activity arises from the perception that the social context determines economic behavior. The markets themselves involve networks, and in addition to analyzing the interaction between which an agent transacts with another agent, it is also important to consider the existence of networks in the information transmission about possible transactions.

Through the existing literature, briefly reported in the previous subsections, it is understood that the insertion of the economic agent in a society allows him to acquire information, interact with other economic agents and also disseminate his own information to other agents (Akçay & Hirshleifer, 2021; Bikhchandani et al., 1992, 2021; Hirshleifer, 2020a; Hirshleifer & Teoh, 2009; J. Park et al., 2013).

However, it is also observed that the MFT paradigm, despite undergoing changes with the inclusion of contexts and influences from behavioral economics, questioning the "normal science," as called by Kuhn (2017), is still in a period of formation and construction. Thus, it can be seen that the incorporation of social finance to BF and, consequently, to MFT seeks to expand the tools available for understanding economic agents, taking into account other characteristics of society and network life, phenomena that have not been so explored yet by BF (Hirshleifer, 2020a).

Still, it is seen that the interaction of the economic agent and his decision-making, besides being a result of his life in networks (Jackson, 2009), is also a product of psychological, individual, and social combinations of investors. Therefore, the present study seeks to validate the interaction between some factors that justify investor movements based on their behavior in society (or in networks), as discussed by (Hirshleifer, 2020a; Hirshleifer & Teoh, 2009; Jackson, 2009) but also seeks to validate characteristics inherent to the investor, such as bounded rationality.

Regarding what the literature has already empirically investigated on the topics addressed, in particular the social transmission bias, it is observed that most studies address informational cascades as an object of analysis. Analyzing empirically, Alevy et al. (2007) modeled an experiment where they verified whether agents update their information and attitudes consistently with Bayes' rule. When comparing students and professional investors, they observed that students adapt their beliefs more when they receive new information (Bayesian thinking) than professional investors. However, such behavioral discrepancy did not provide differences in the financial returns of each group.

Furthermore, in the same study, it was noticed that professional investors could better distinguish the quality of the private signal announced by other students. That is, the decision-making process of that observed group is more sophisticated, which leads investors to trust their private signal a greater number of times, resulting in less frequent informational cascades. The difference lay in professional investors learning, throughout the experimental session, to think about the quality of other people's decisions, whereas college students did not. Therefore, the authors admit that their results "emphasize the potential for cascade fragility arising from variation in the ability to interpret signal quality may be important in this context" (Alevy et al., 2007, p. 174).

Brunner and Goeree (2009) conducted an experiment where they sought to observe agents' learning based on private signals and publicly available information. They intended to verify whether economic agents could act rationally and follow the minority of other agents when this minority was shown to be correct (holding a correct private signal). Their results showed that even though some agents could sequentially observe the decision-making of other agents, in most cases, agents choose to follow the majority, even if this decision is mathematically incorrect.

Anderson and Holt (1997) tested information cascades in a laboratory with economics students at the University of Virginia (USA) and obtained results where it was possible to verify the emergence of cascades where agents' private information was no longer taken into account, and they preferred to follow most agents who made the decision beforehand and made it public. Nevertheless, on other occasions, some sequences of decisions resulted in reverse cascades, i.e., "where initial misrepresentative signals start a chain of incorrect decisions that is not broken by more representative signals received later" (Anderson & Holt, 1997, p. 859).

Also, the authors identified some systematic errors in the participants, which, according to them, would be due to representativeness bias (when agents tend to underestimate prior probabilities and focus on the similarity of their sample with a given population) or counting heuristic (tendency to judge events by their frequency rather than their impact). In the analyzed sample, they observed that the most prevalent systematic bias was the tendency of about ⅓ of the participants to rely on simple signal counts rather than the Bayes rule (overall, only ⅓ of deviations from the Bayes rule in the asymmetric design could be explained by counting) (Anderson & Holt, 1997, p. 859).

Further on, Duffy et al. (2019) improved the work carried out by Anderson and Holt (1997), basing themselves on the same methodological design but adding a participant's choice option: obtaining a private signal or observing social information (the decision-making sequence of agents predecessors).

Their results showed that individuals exhibit a suboptimal bias, where they choose to observe social behavior (choice or behavior of predecessor agents) instead of holding private information. Still, they mention that the general bias they identified was that "the overall bias we identify is that social information is chosen more often and earlier than it should be, as the empirically optimal strategy here is to always choose private information." (Duffy et al., 2019, p. 296). I.e., they identified that agents use the heuristic "more is better" when evaluating social information. However, this heuristic incurs an information cascade with less informational value.

Still, Duffy et al. (2019, p. 308) commented that, in their results, "when a subject's decision can be observed by followers, she chooses private information more frequently than when there are no subsequent players," which agrees with what was also observed by Brunner and Goeree (2009).

Despite this, Kübler and Weizsacker (2004) also modified the experimental design of Anderson e Holt (1997), making public social information available to all agents and giving participants a choice to obtain private information at a small cost. This methodological design expected that only the first participant would acquire private information. However, the results showed an excessive purchase of private information.

Çelen and Hyndman (2012) made the opposite methodological modification in the work of Anderson e Holt (1997): agents could choose the choice of predecessor agents (the social choice) at a cost, while private information was available to everyone. Their result was similar to that of Kübler and Weizsacker (2004): the excessive acquisition of information that was not freely available.

The literature observes methodological modifications and different experimental designs for the analysis of information cascades or social learning, where some authors, such as as seen in (Choi et al., 2012; Duffy et al., 2019, 2021; Frydman & Krajbich, 2022; Goeree & Yariv, 2015).

Weizsäcker (2010), in his meta-analysis work, gathered about 30,000 decisions over 13 studies that were based on the methodology modifications of the study of Anderson and Holt (1997) and, when analyzing this new set of information, he admits that in many cases, study participants should contradict their private information, in an empirically optimal way, but only do so in less than 50% of occasions. However, when the private signal confirms the empirically desired action, they act in an optimal way in 90% of the situations.

Angrisani et al. (2021, p. 164) admit that some biases end up standing out in the social learning process. The neglect of information redundancy (correlation neglect) and the tendency for individuals to value their private information more than the public information within other participants' choices. In their empirical analysis, they added the overconfidence bias within the study of the social transmission bias. The authors point out that agents may not consider that they were influenced by the same source of information or even consider themselves better decision-makers than others, thus showing an excess of confidence.

Based on what has been studied in the existing literature so far, a predominance of information cascades or social learning studies was observed. However, no empirical studies have yet been found that test the social transmission bias specifically, as mentioned in the previous subsection. Regarding empirical tests, when observing a minority of the population holding information, only Brunner and Goeree (2009) chose this methodological option.

Furthermore, it was possible to verify that studies on information cascades, in general, analyzed and compared two states of the world and the perception of agents/participants about their individual choice based on the private information held or the public/social information. Therefore, situations in which social transmission takes place based on past financial returns, as discussed in section 2.2.1, have space for some research, as no experimental design was found in which participants reported their gains resulted from riskier strategies and with higher returns.

3.1 THESIS STATEMENT

Based on the thought that the social transmission bias is inherent to the context of a society in which economic agents are inserted: markets where there are interactions between them, conversations, and dissemination of public information, the thesis defended in this work is:

Economic agents share information and systematically modify their decision-making to maximize their utility within the limits of their rationality. In this process, they often disregard their private information.

4 METHODOLOGY

4.1 RESEARCH DESIGN

This research investigates the problem statement using exploratory and explanatory approaches. The analysis procedure can be described as quantitative. Statistical tests were performed using *Stata MP*, mainly logistic regressions, and *Wolfram Mathematica* software was used for data visualization. Concerning the time perspective, it can be considered a cross-sectional study because it analyzes data from a population at a single point in time. The population selection used probability sampling, more specifically, simple random sampling.

Regarding the methodology adopted in this study, a rationality experiment was conducted to see if economic agents were able to understand that following the minority in some circumstances is the best strategy. The experiments were carried out on computers using the *z-Tree* software (*Zurich Toolbox for Readymade Economic Experim*ents) developed by the University of Zurich.

The experiment consisted of presenting to the participants a situation in which: an A or B "state of the world" was drawn randomly, and the participants had to choose between option A and option B, aiming the correct option.

Participants were not informed of the state of the world result at the start of each round. The decisions of each participant were taken sequentially. There were two treatments: in one treatment participants observed the total number of players who had chosen each option. On the second treatment of the experiment (as it was called to subjects "Phase 2"), they could observe the decision-making sequence of the previous participants (that is, the history of choices from that round).

In the first treatment, one sought to verify whether the "wisdom of minorities" could emerge. The idea was that participants had to choose between 2 options, and one of them was better than the other (e.g., good restaurant *vs*. bad restaurant).

The choice alternatives had the same color, format, and size and were empty of any identification that could induce an exogenous preference of the participant (favorite color, favorite number, the first letter of the participant's name, etc.). Such experimental justification has a theoretical foundation in the mathematical model proposed by (Callander & Hörner, 2009a). Therefore, the options were called Restaurant ☆ and Restaurant ✤. The experimental modifications aim to help answer all the objectives proposed in subsection 1.2.2.

The sessions consisted of 6 participants, according to feasible mathematical probability, following the model by Callander and Hörner (2009). In each round, there was 1 participant who was better informed than the others. He had a private information, which revealed (only to him) which was the correct alternative in that round (i.e., probability $f = 1/6$). The other participants knew of the existence of an informed participant, but he was anonymous.

At the end of each round, the participants were revealed what the state of the world was and what the correct alternative that characterized "victory" was. Participants who chose the correct alternative won 10 points in each round. Afterward, a new round started, and the state of the world and the better-informed agent were drawn again.

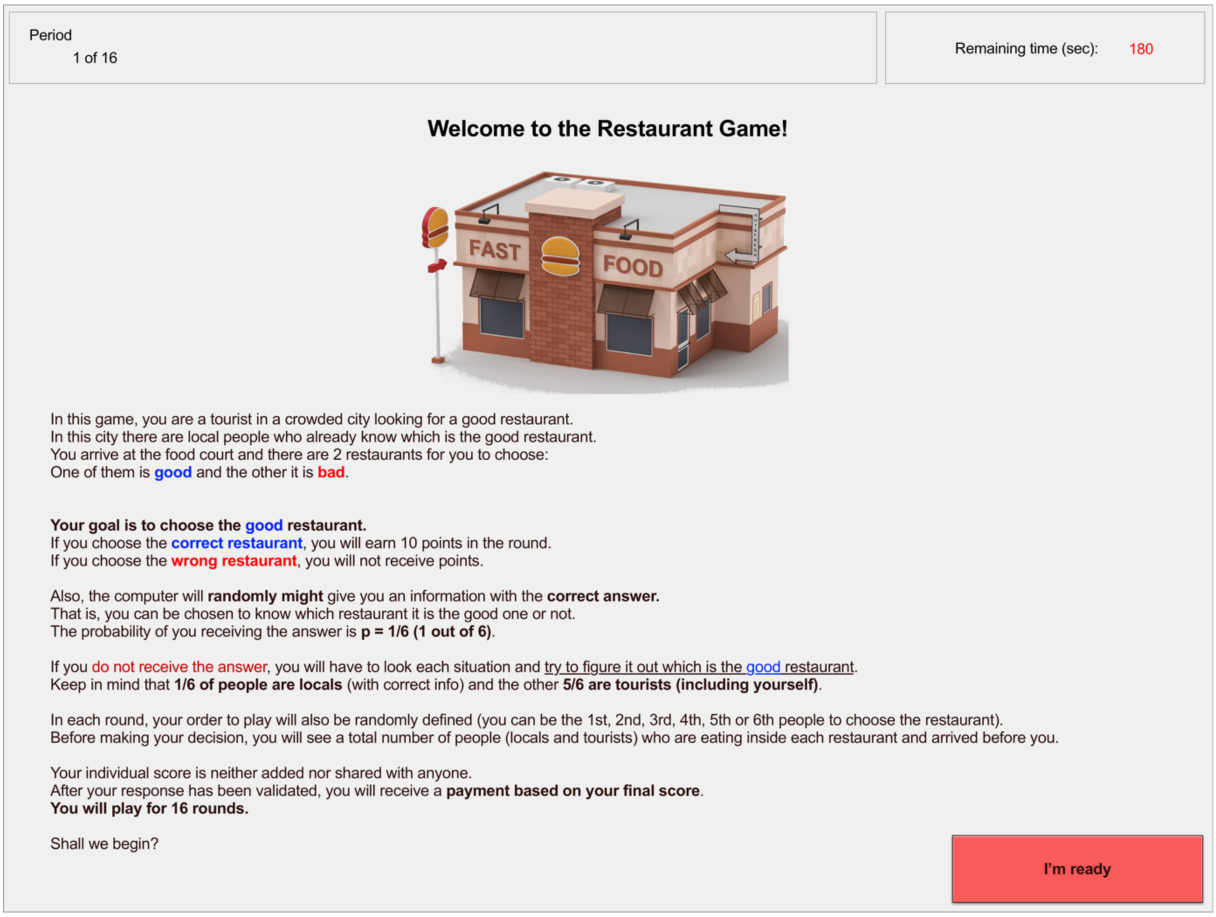
At the end of 16 rounds, the participants' scores were added up, and cash payments were made based on their performance. Each participant also received a participation fee. After the experiment, each person was submitted to a three-question cognitive reflection test with counterintuitive questions and a brief socio-demographic questionnaire.

4.2 EXPERIMENT 1

As discussed above, the first experiment was conducted to see if economic agents understand that following the minority in some circumstances is the best strategy. The experiment was programmed in *z-Tree* and is named "Restaurant Game."

The game consisted of 6 players who were arranged in 16 rounds, in which in the first 10 rounds, they played the non-sequential treatment, and in the last 6 they played the sequential treatment. The difference between the treatments is that on the non-sequential treatment, they only saw the total number of players that had chosen each restaurant. On the sequential treatment, they were able to see which player had chosen each restaurant and in what order they had chosen. The screens shown to participants can be seen in Figure 4 (and also in Appendix A).

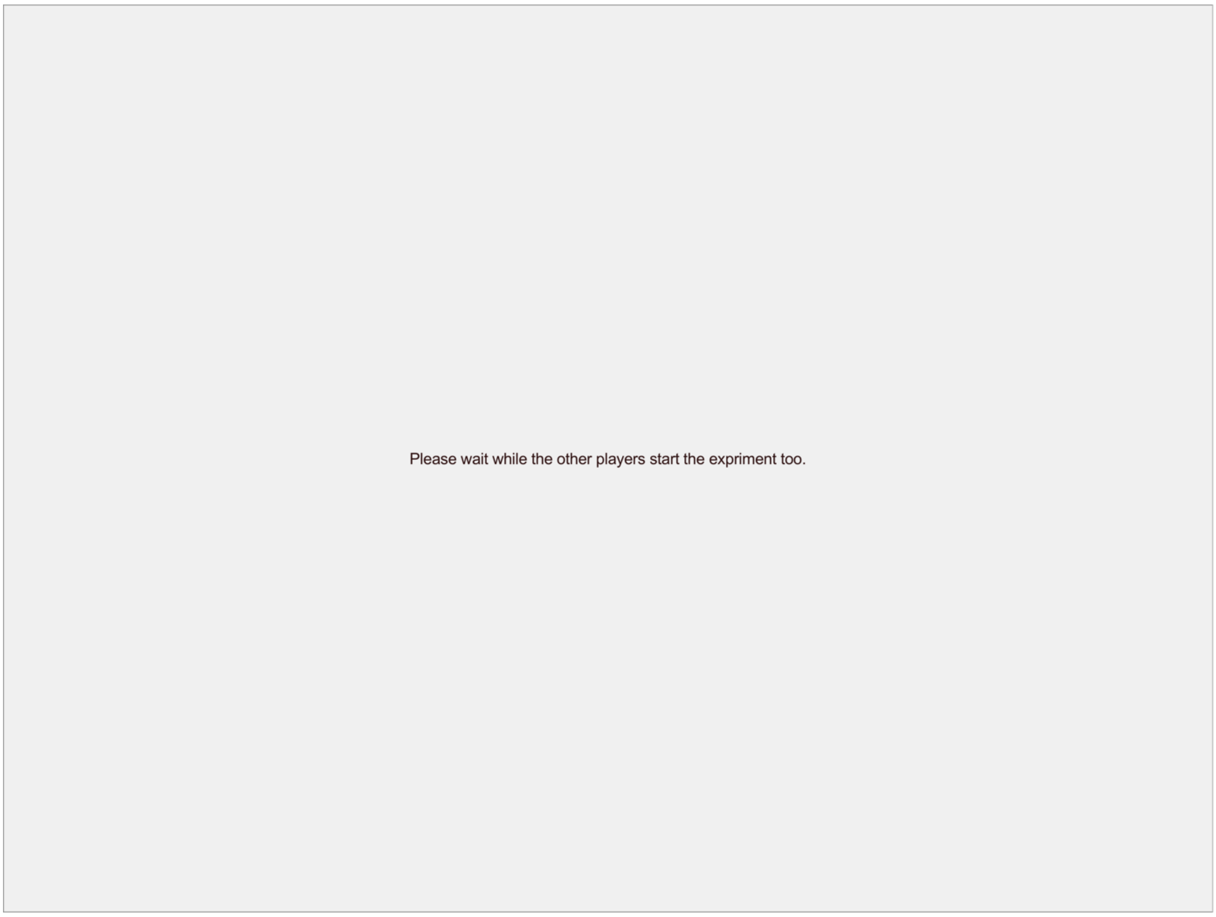
Figure 4 – Initial screen: experiment 1 participant instructions



Therefore, the probability f of being an informed player in this experiment is 1/6 (0.1667). Also, it is established that the probability p is the quality of information of the less informed player, and the probability q is the quality of the information given to one of the players in each round. In experiment 1, these probabilities are: $p = 0.50$ and $q = 1.0$, so the uninformed players have a 50% of choosing the correct restaurant (1 out of 2 available options), and the informed player was 100% sure about which restaurant is the good one.

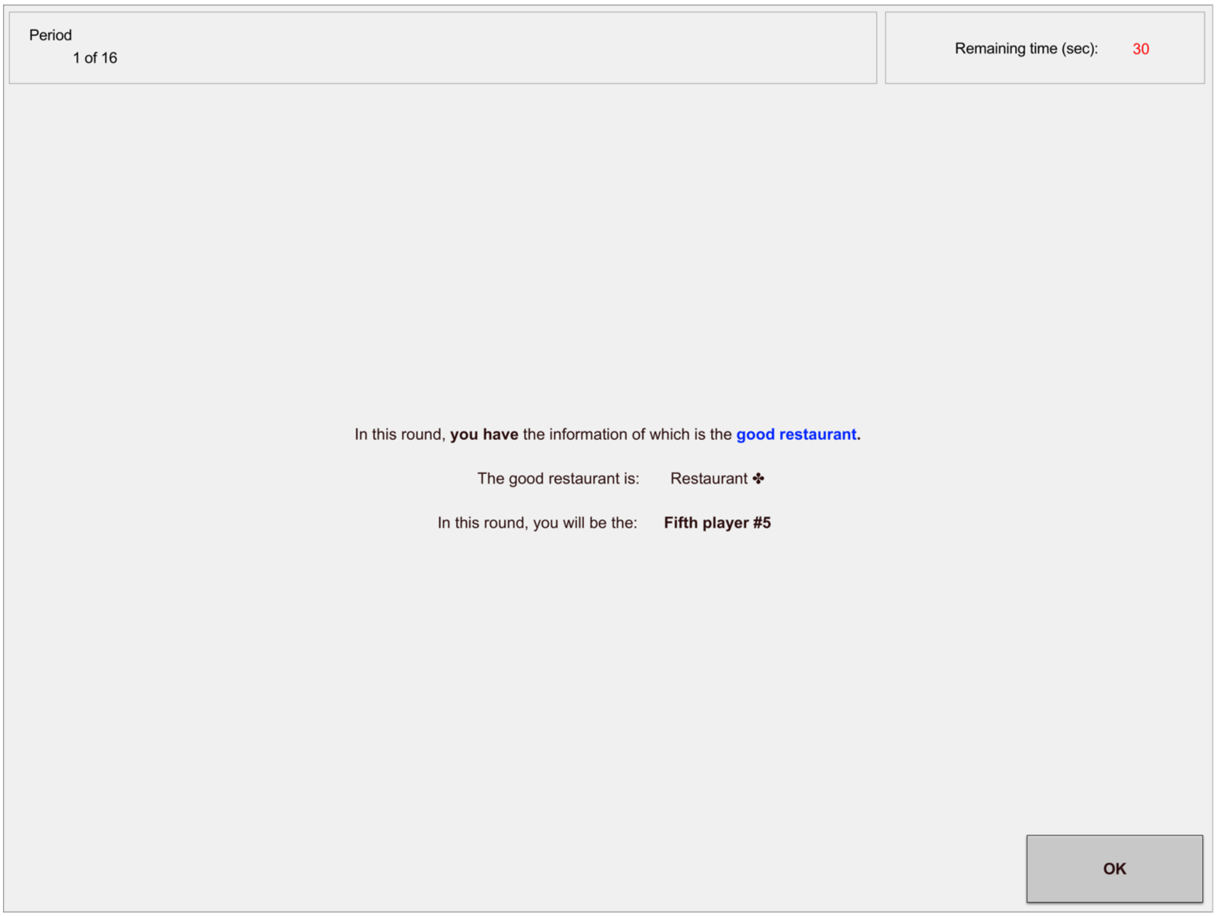
Figure 4 contains the initial instructions for the Restaurant game and will be shown to the participants, who, when clicking on the "I'm ready" button, were redirected to the waiting screen until all participants start the experiment (see Figure 5). The goal of the "Restaurant Game" was to guess which was the good restaurant. It was the Restaurant ☆ for the given world state A and it was the Restaurant ✣ for the given state world B.

Figure 5 – Initial waiting screen



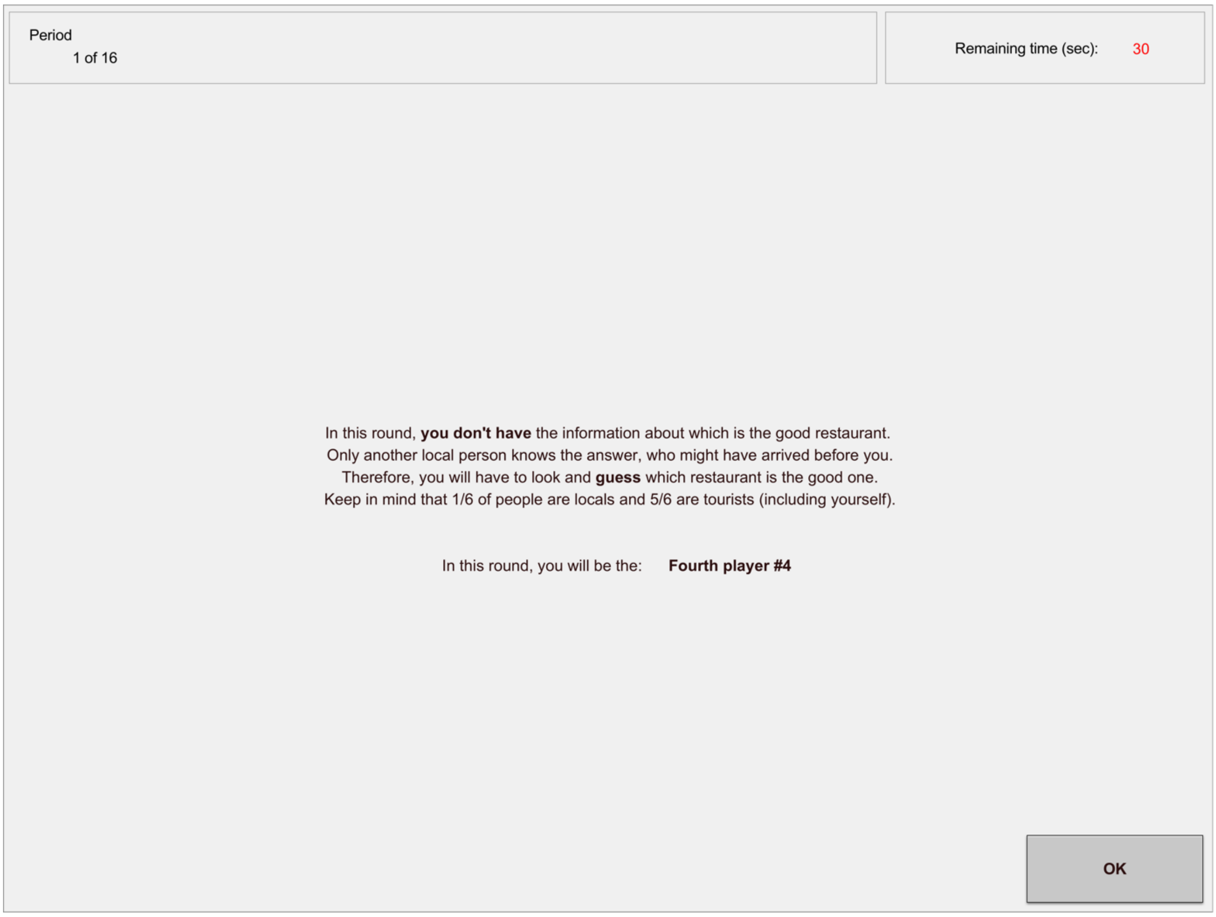
From that moment on, a participant was randomly chosen and was informed which restaurant was the correct one on that round. At that moment, the player was also informed in which order he would play in that round (first to make the decision, second to make the decision, third to make the decision, fourth to make the decision, or fifth to make the decision, or sixth (and last) to make the decision). For the player who held the information in that round, the following screen was displayed (figure 6):

Figure 6 – Screen of the player who holds the information



In the example above, the good restaurant door in this round was the Restaurant ✤ door and the participant holding the information in this round was the 5th player to decide. For the other participants of that round, who did not have the correct answer information, the following screen was displayed (figure 7):

Figure 7 – Screen of the player who does not have the information



In this example, it is observed that the participant was, in this round, the 4th player to make the decision and that he did not have the information. It was emphasized to him that another player had the correct information and that another player may had made the decision before or after him. I.e., he only knew that someone had the answer, but not who it was or when that person would make the decision. It was up to the uninformed player to observe and analyze the behavior of the decisions taken previously to guess the correct answer.

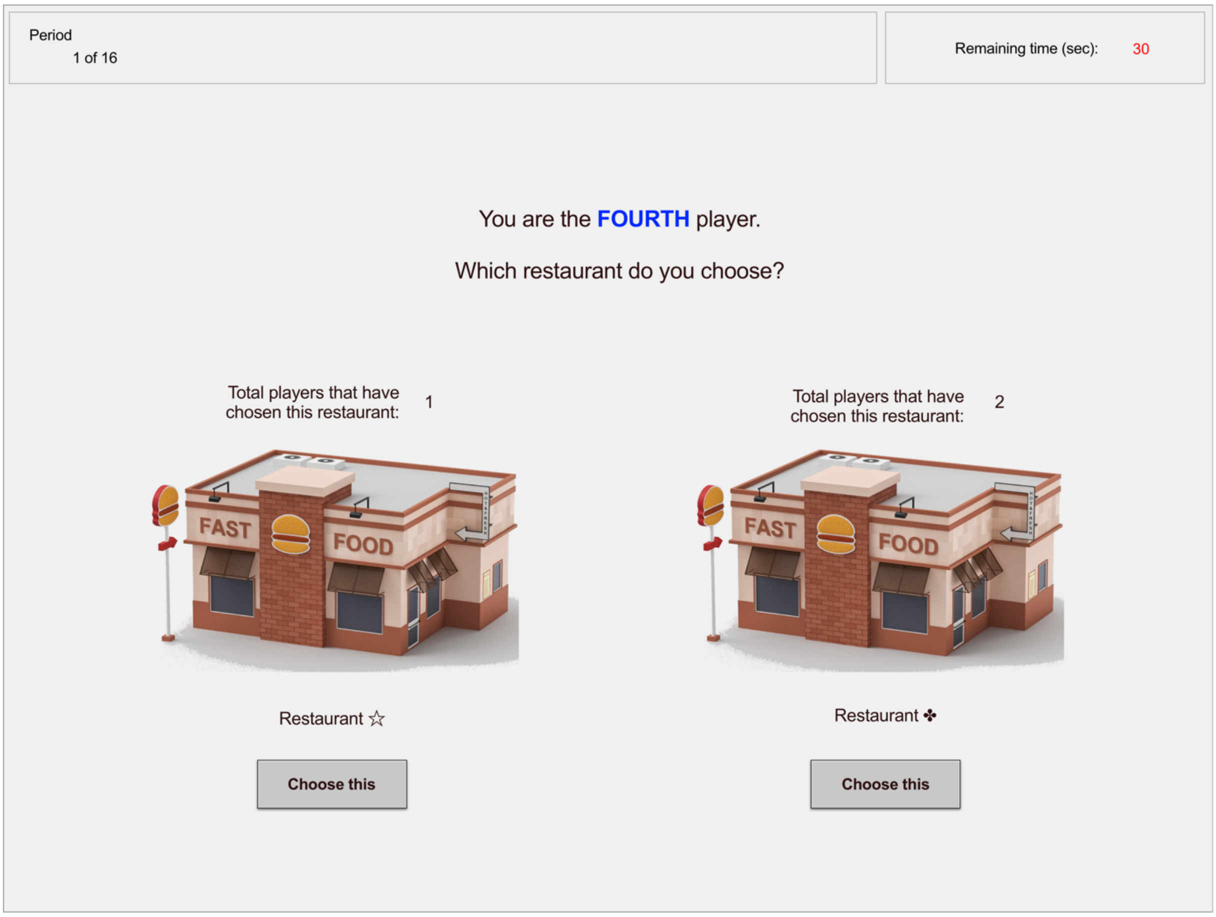
After giving the first round of information, the players were asked if they had understood the game. If they are ready to start, they should click on the button "Yes" (figure 8).

Figure 8 – Game understanding check

Starting with decision-making, the first player was asked which restaurant he believed to be the good one. If the first participant to make the decision was uninformed, he probably chose at random.

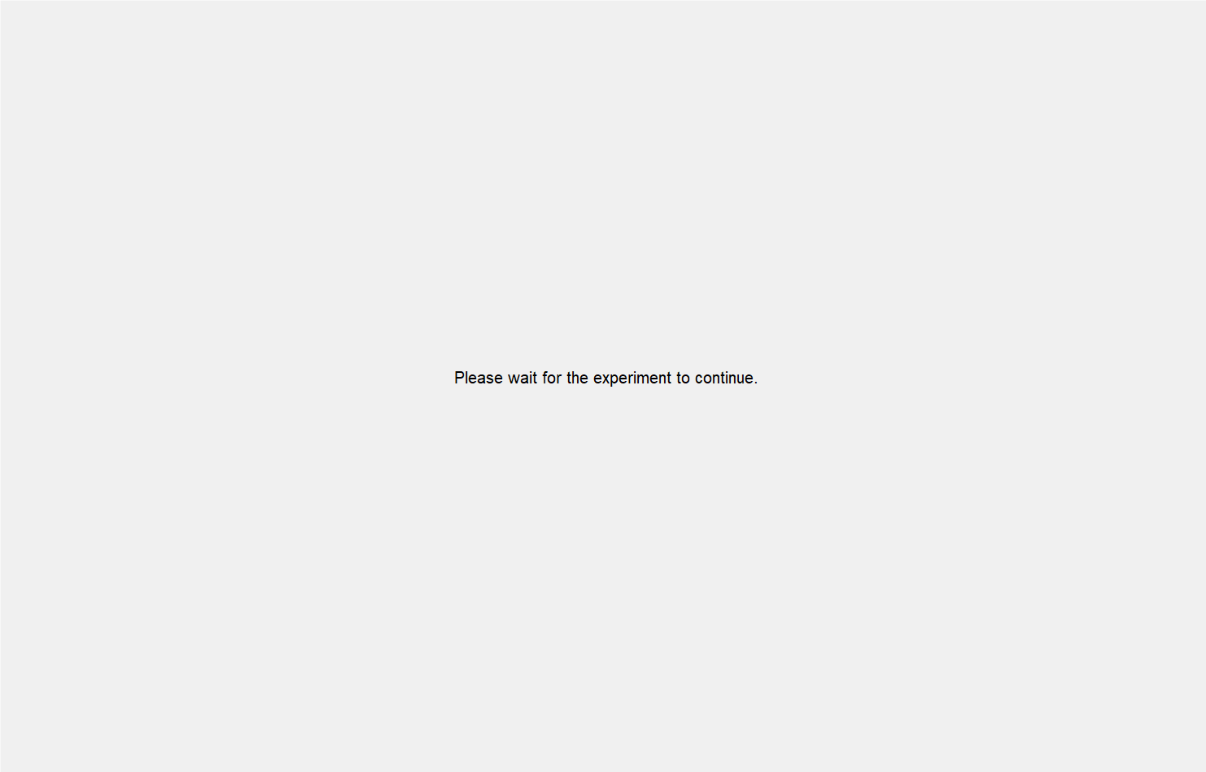
Next, the following players were shown screens containing buttons for them to make their choices (Restaurant ☆ or Restaurant ✤). However, they were also shown the total number of people who had previously chosen each of those alternatives up to the moment of their turn (see Figure 9). This is the main characteristic of the non-sequential treatment. The decision screen is displayed one at a time for each player, as decision-making occurred sequentially. I.e., the participant assigned as the 3rd player in that round only had his decision screen displayed (and was able to make his choice) after the 2nd player of that round had finished his move. And so on, successively until the 6th player and the end of that round.

Figure 9 – Decision screen – fourth player of the round



Afterward, he was presented with a waiting screen (see Figure 10), which remained displayed until all the other players made their decisions.

Figure 10 - Waiting screen



When the sixth player finished his decision, the round ended. Therefore, in the sequence, to each player was displayed a screen containing information about which was the good restaurant in that round. For the player who chose the good restaurant (see Figure 11), 10 points were added to their individual score. No points were added in that round for the player who chose the wrong restaurant (figure 12).

Figure 11 – Outcome of the round – player with correct answer

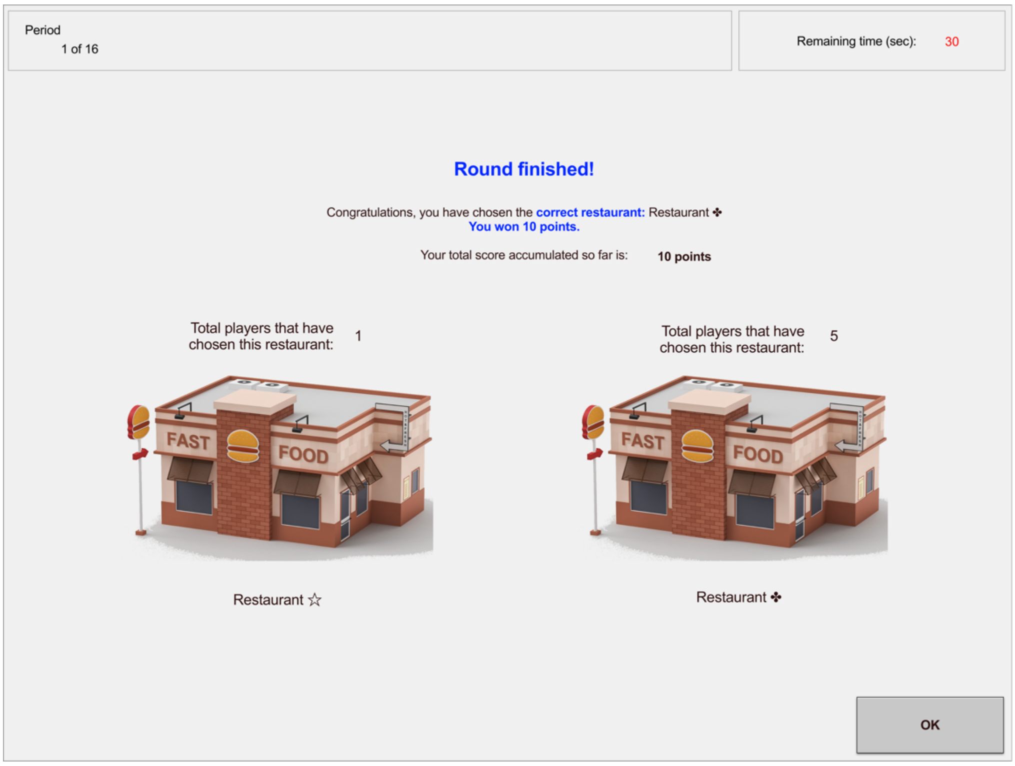
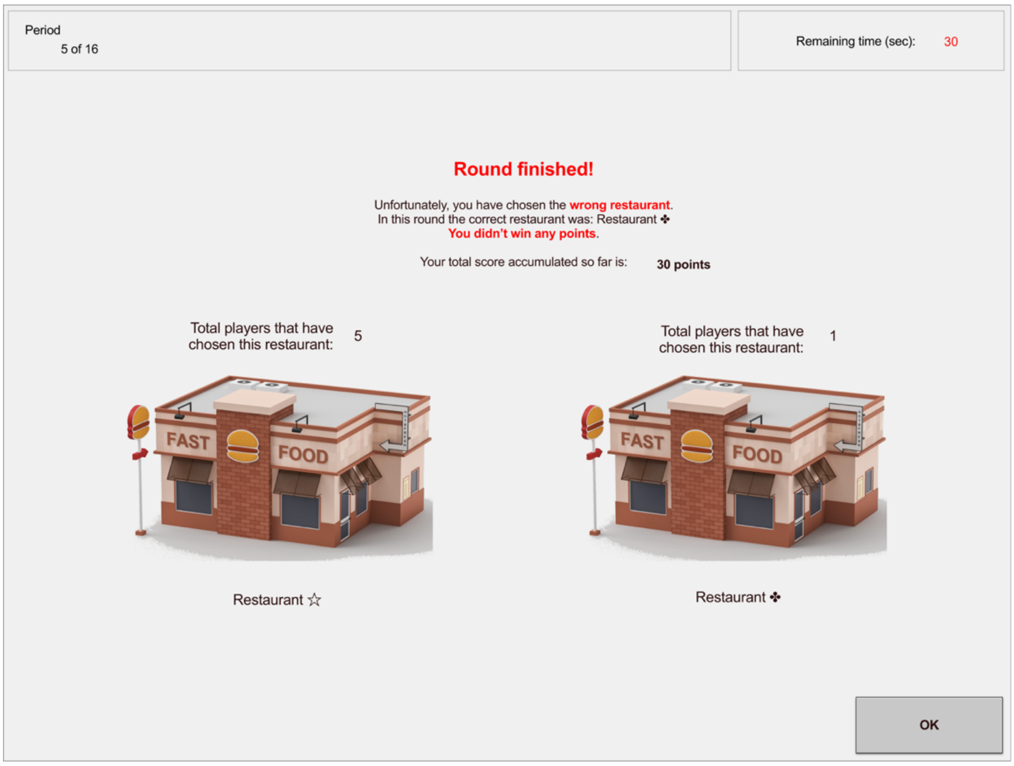


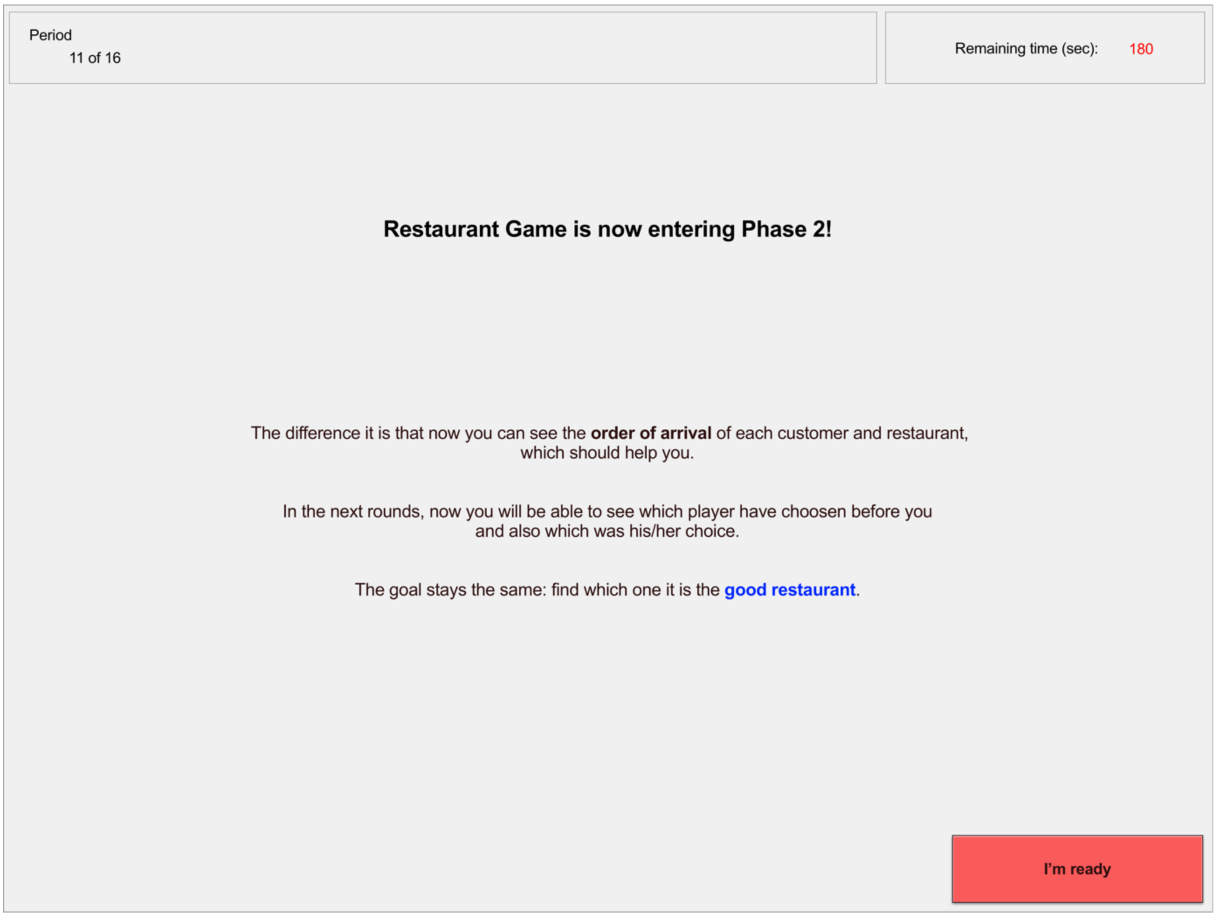
Figure 12 – Outcome of the round – player with incorrect answer



Figures 11 and 12 show that, at the end of each round, the participant will also be informed of his/her individual score accumulated so far.

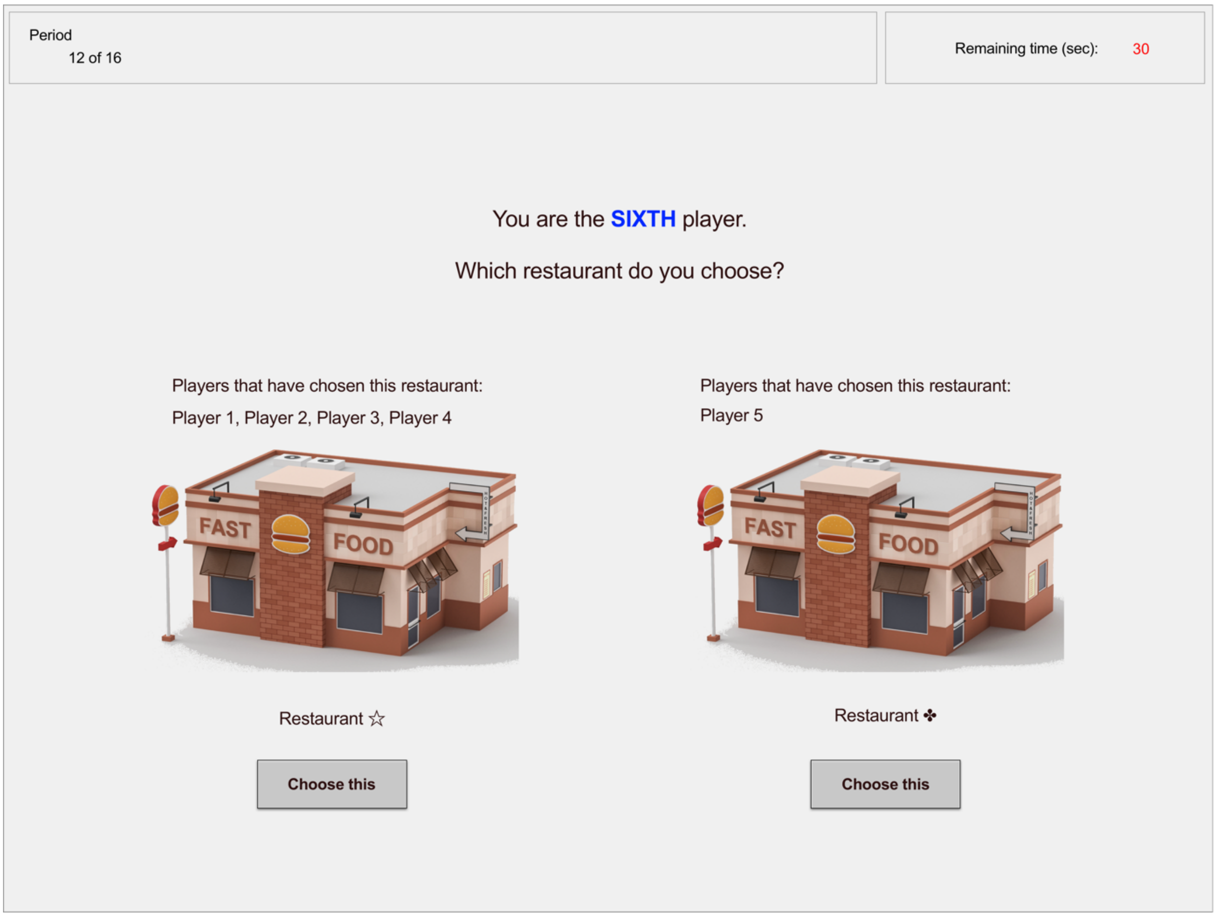
After 10 rounds, the players entered the second phase of the experiment, i.e., the sequential treatment. The following instructions were shown to them, aiming to explain the game's new rules. Although there were slight changes in the rules, the goal is the same: to guess which is the good restaurant. The instructions for the phase were displayed as Figure 13 shows:

Figure 13 – Phase 2 instructions



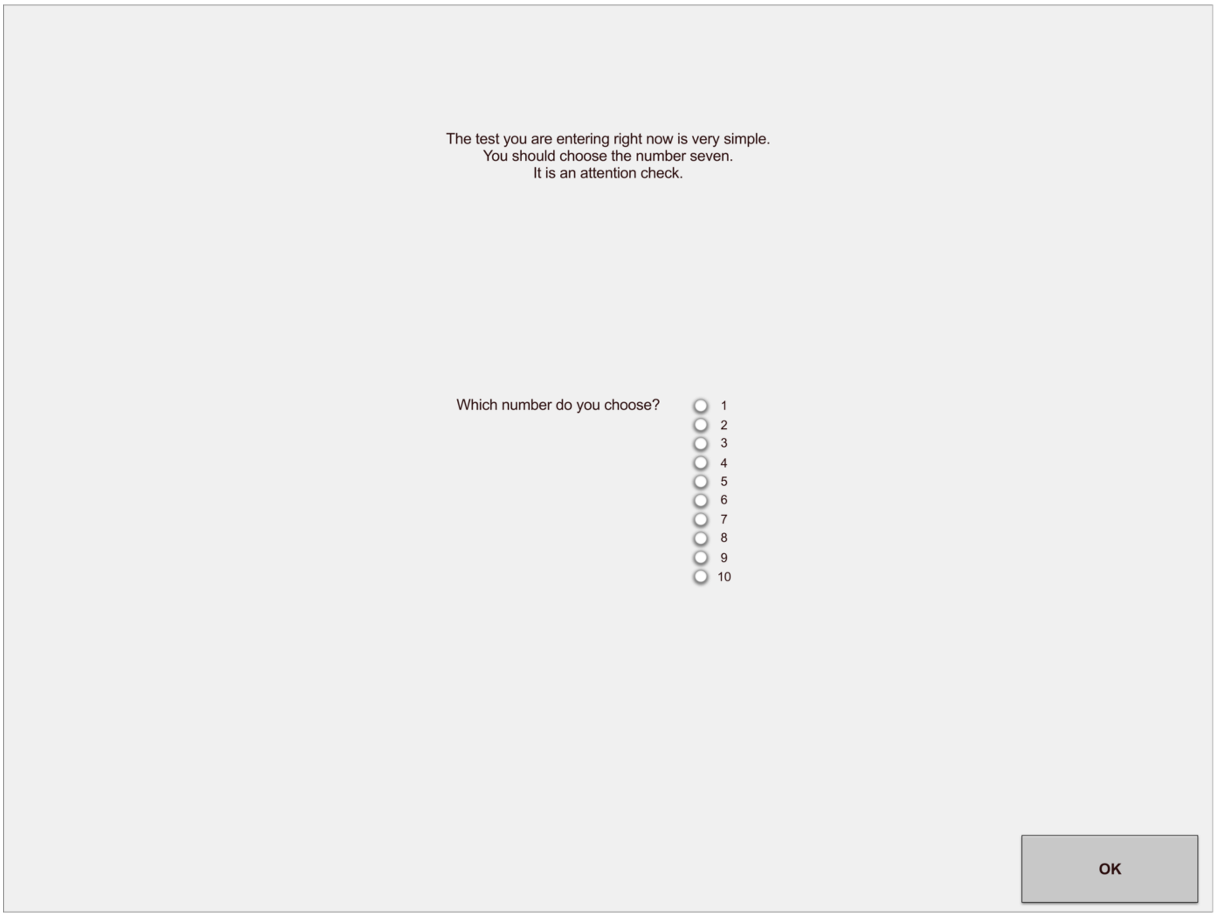
For this new treatment, as said before, the players saw how many had chosen each door and also their order of play. The screen shown to the players, from now on, was like Figure 14:

Figure 14 – Sequential treatment screen



During the experiment, attention checks were made to check the player's attention to the game. They were simple questions, but they aimed to eliminate participants who answered incorrectly, meaning they were probably answering randomly just to finish the experiment. The first attention check was shown after round 7, and players were asked to choose a specific option between the numbers. Furthermore, they were shown a bunch of colors, and they were asked to type a specific one. An example of an attention check is visible in Figure 15:

Figure 15 – Attention check question



If the player failed one or both attention checks, his/her participation was excluded from the analyzed data.

4.2.1 Cognitive reflection test

After round 16, the experiment proceeded to the next stage, which consisted of a cognitive reflection test. The test contained three questions, and players had a limited time (thirty seconds) to answer each one. For each question, there was only one correct answer. The result of these questions did not influence the participation during past rounds of the "Restaurant Game," nor the final individual score, nor the amount paid to each participant at the end of the experiment. This information was explicitly shown to them.

Based on the theory that the human brain is composed of two cognitive systems, called "System 1" and "System 2" (Kahneman, 2012), the CRT consists of tests for participants to verify which system the individual would use to make his decision. CRT test questions have an incorrect intuitive answer, usually "sent" by "System 1". However, after some deliberation and reflection (completed by “System 2”), the correct answer can be calculated (Brañas-Garza et al., 2019). Frederick (2005) originally proposed the CRT, which has been replicated in the literature to predict the decision-making process (Andersson et al., 2016; Besedeš et al., 2012; Campitelli & Labollita, 2010; Hoppe & Kusterer, 2011; Moritz et al., 2013; Neyse et al., 2016; Oechssler et al., 2009). The CRT questions can be consulted in Appendix B.

Figure 15 is an example of a screen displayed to the participants so that they could answer each of the questions. Figure 16 is an explanatory screen, and the others are questions with an answer field.

Figure 16 – CRT explanation screen for the participant

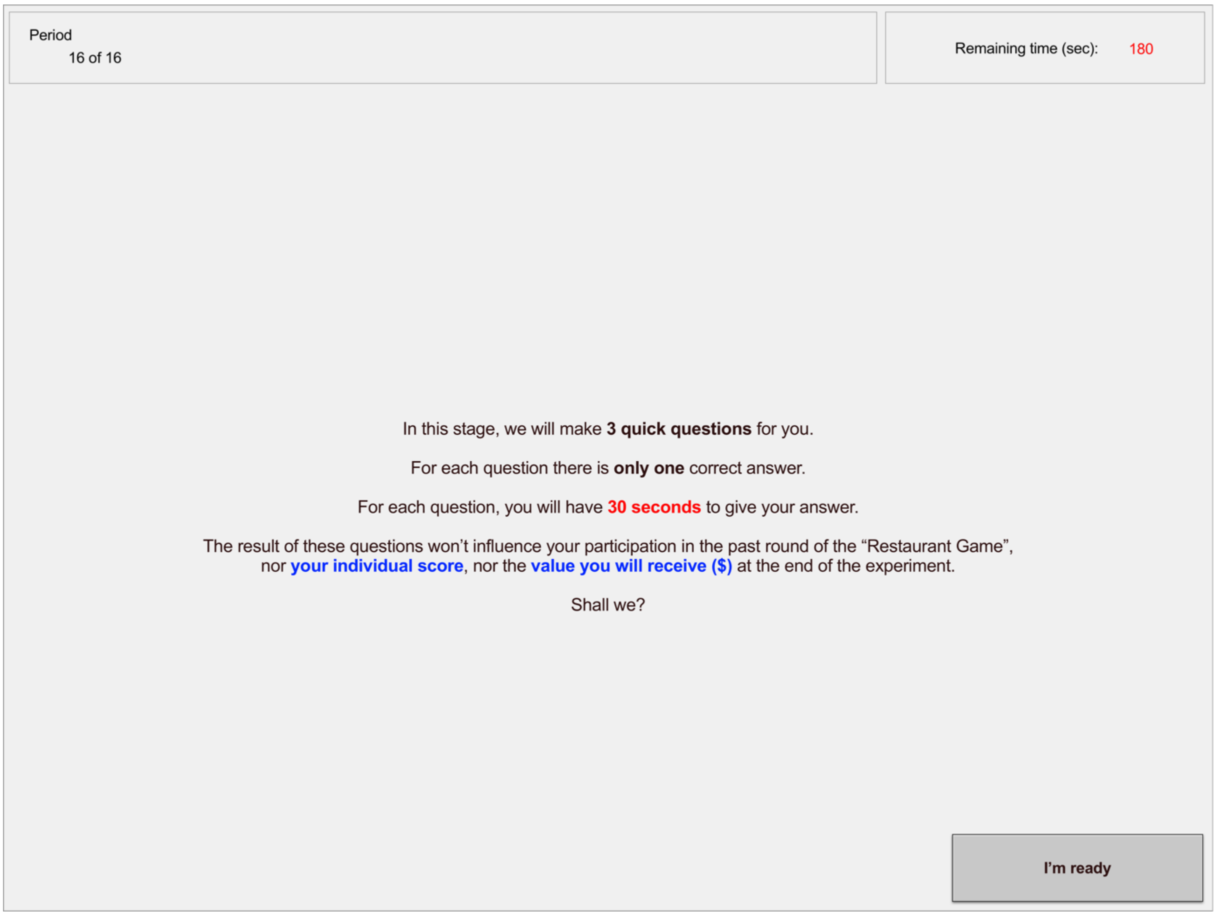
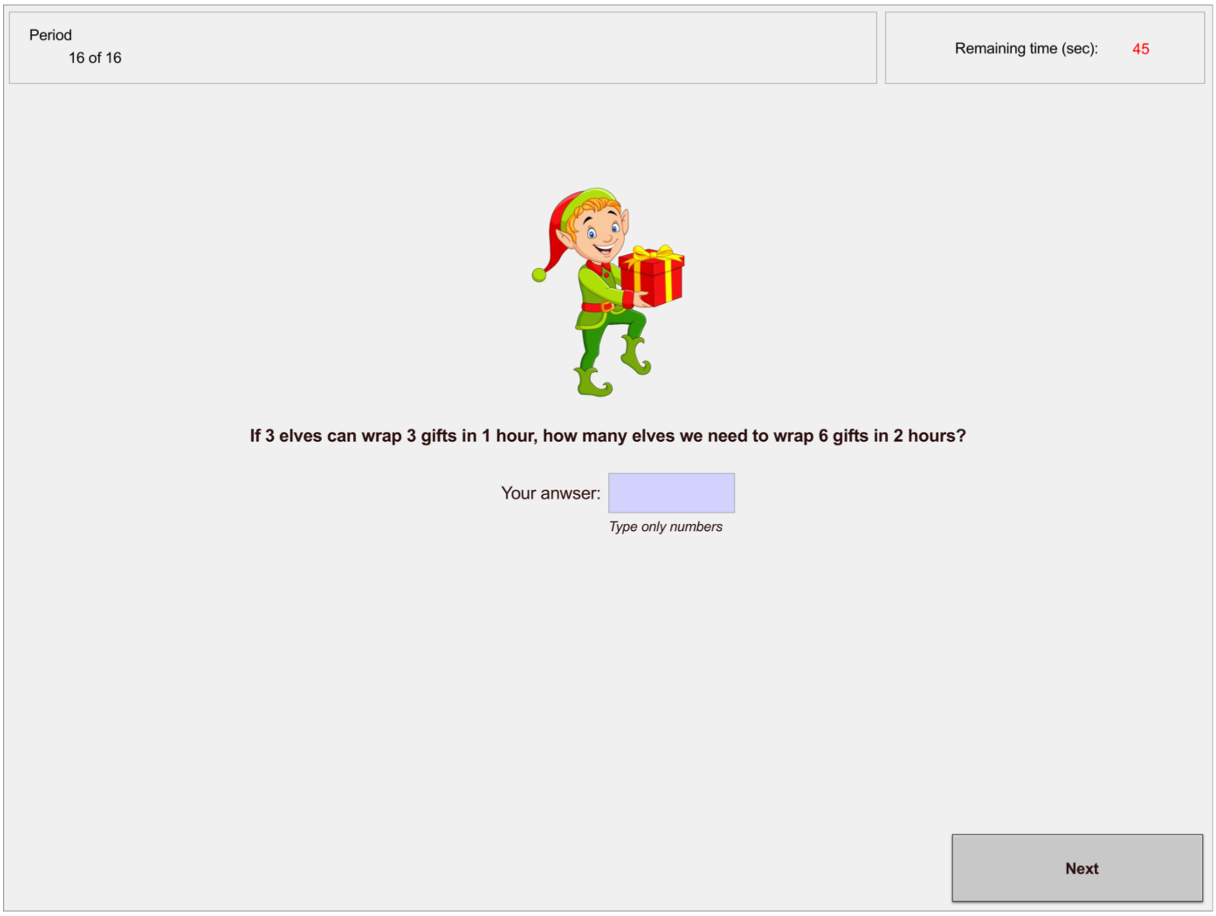


Figure 17 – CRT Question screen



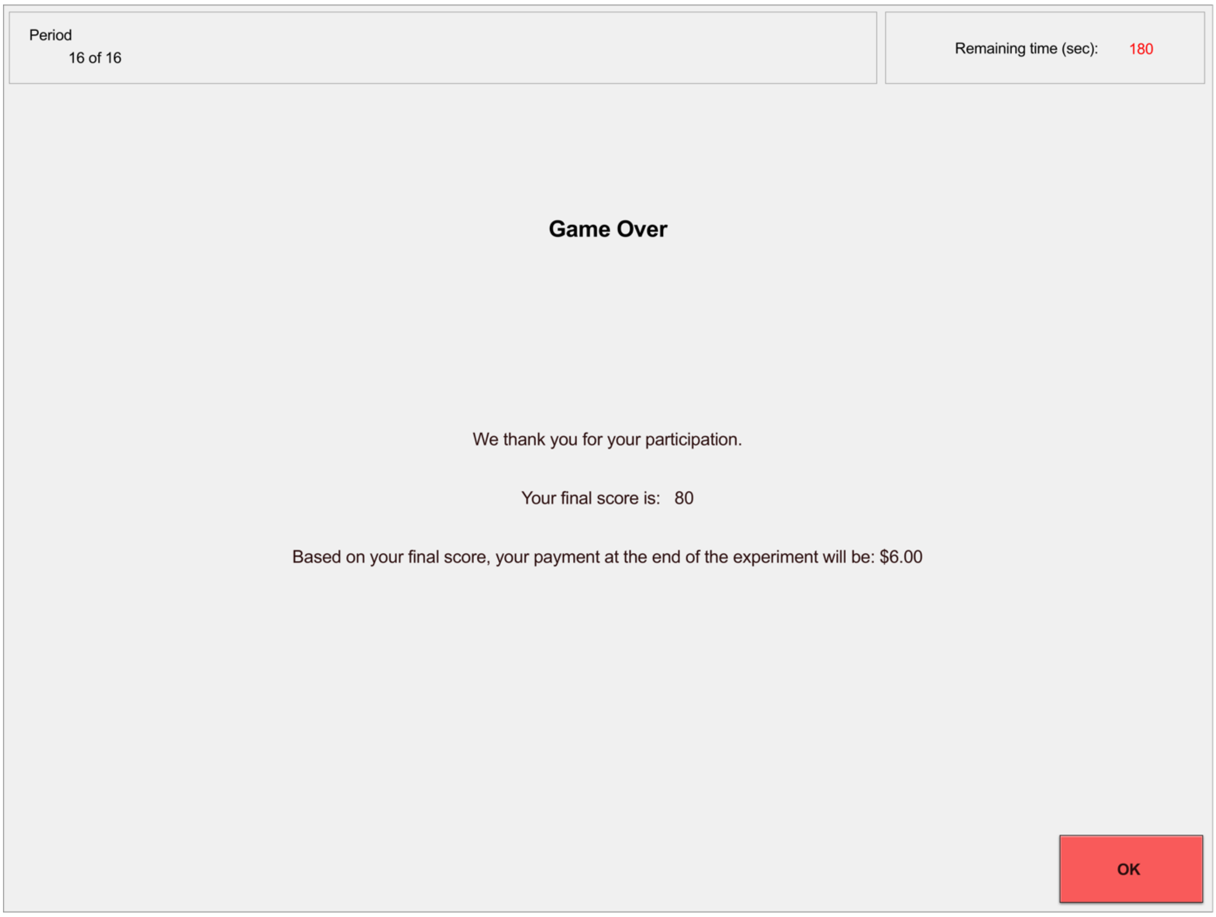
Participants had 30 seconds to answer each question. The remaining time displayed on the screen encouraged the player to make their decision faster, which tested their decision-making. After the third question, the test was finished, and the correct answers were shown to the participants for informational purposes only.

At the end of the CRT test, the participant was shown their individual score accumulated in all rounds and the amount that would be paid to them at the end of the experiment based on their performance during the 16 rounds (see Figure 32). Participants were paid a participation fee. Therefore, the final payoff for each individual (in reais) at the end of the experiment will be given by:

$$payoff(\$) = participation\ fee\ + \left(\frac{final\ individual\ score}{160} \times endowment\right) \qquad (3)$$

The value of the participation fee was \$2.00 and the maximum possible amount paid (endowment) was \$8.00.

Figure 18 – Final performance screen



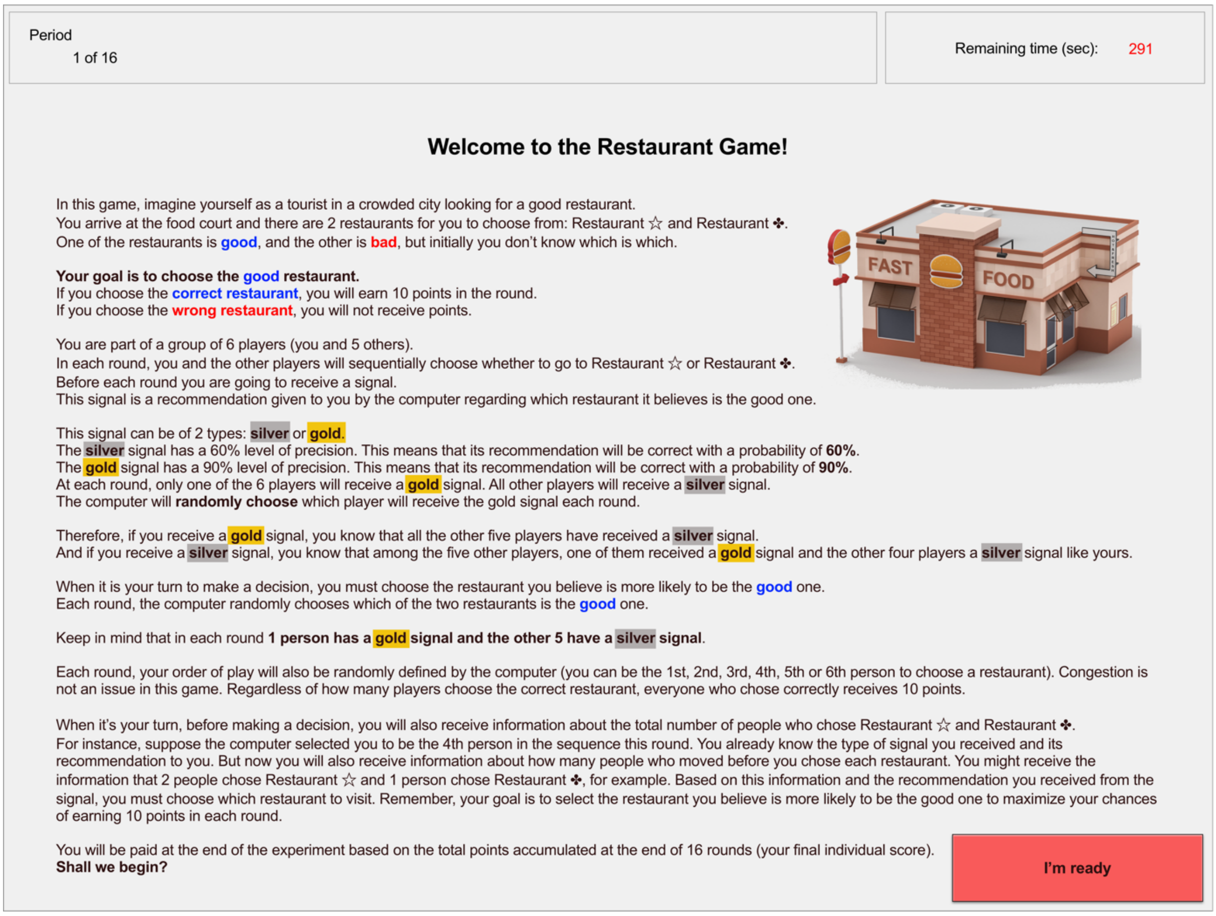
Between each round, each participant was asked what factor motivated their decision-making. This questioning aimed to understand and identify if/when there was a learning curve or which strategy participants adhered to. Answering these questions was not obligatory. Afterward, the experiment will proceed to stage 3, consisting of a sociodemographic questionnaire (questions are listed in Appendix C).

4.3 EXPERIMENT 2

The second experiment can be seen as a derivation of experiment 1. Changes were made in the probabilities that involve the quality of the information given to the players. Experiment 2 will change these probabilities: $p = 0.60$ and $q = 0.90$. Therefore, in experiment 2, all players received some information, which was addressed as the "silver signal" or "gold signal". In each round, 5 players received a "poor information" (addressed as silver signal) which was correct in 60% of the cases, and 1 player received a "better information" (called gold signal), which was correct in 90% of the cases. According to calculations by the model proposed by Callander and Hörner (2009a) minority wisdom should appear, but we expect that there will be changes in players' behavior. The probability *f* of being (relatively) informed in experiment 2 was also 1/6 (the same as in experiment 1).

In experiment 2, the Restaurant Game was almost the same. The goal of each participant was to guess which restaurant was the good one, they were paired with 5 other players, and had to choose 1 out of 2 available options: Restaurant ☆ and Restaurant ✤. The initial instructions were updated to the new information they needed to know about gold and silver signals. Participants were always new players, i.e., no one who played Experiment 1 could join Experiment 2. The instructions shown to participants at the beginning of the experiment can be seen in Figure 19 (also available in Appendix D).

Figure 19 – Initial screen: experiment 2 participant instructions



As previously stated, in experiment 2, participants received a signal that could be silver or gold. The signal screens containing the information can be seen in Figures 20 and 21.

Figure 20 – Gold signal screen

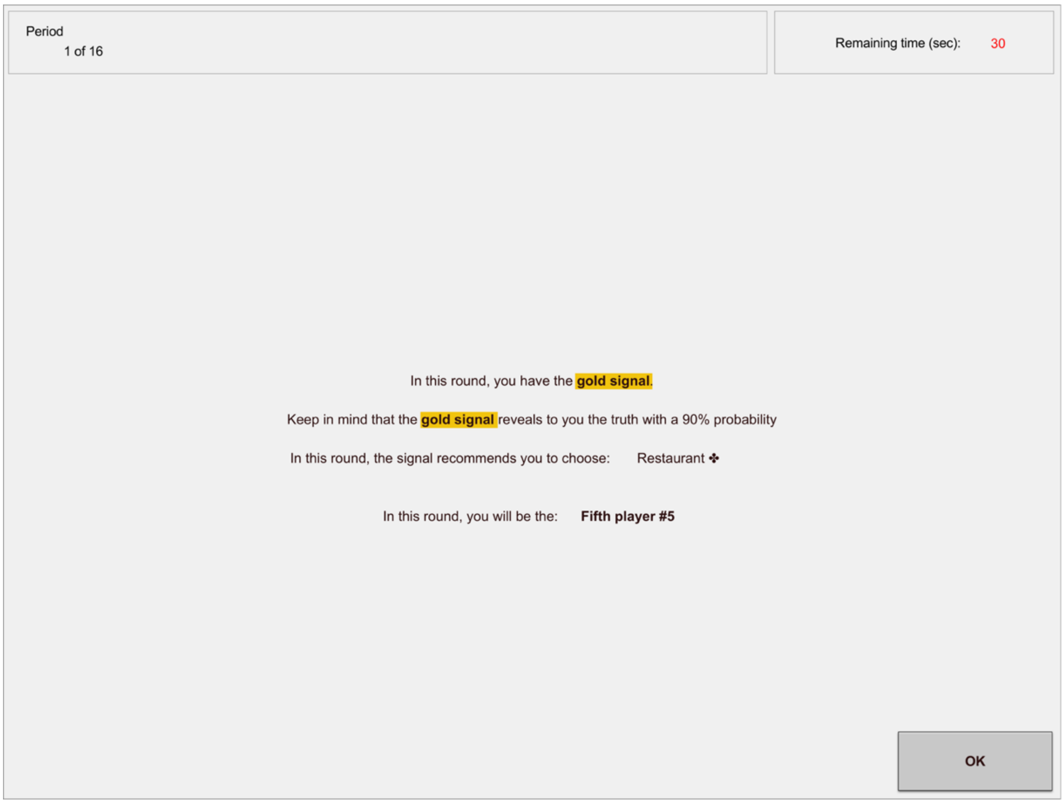
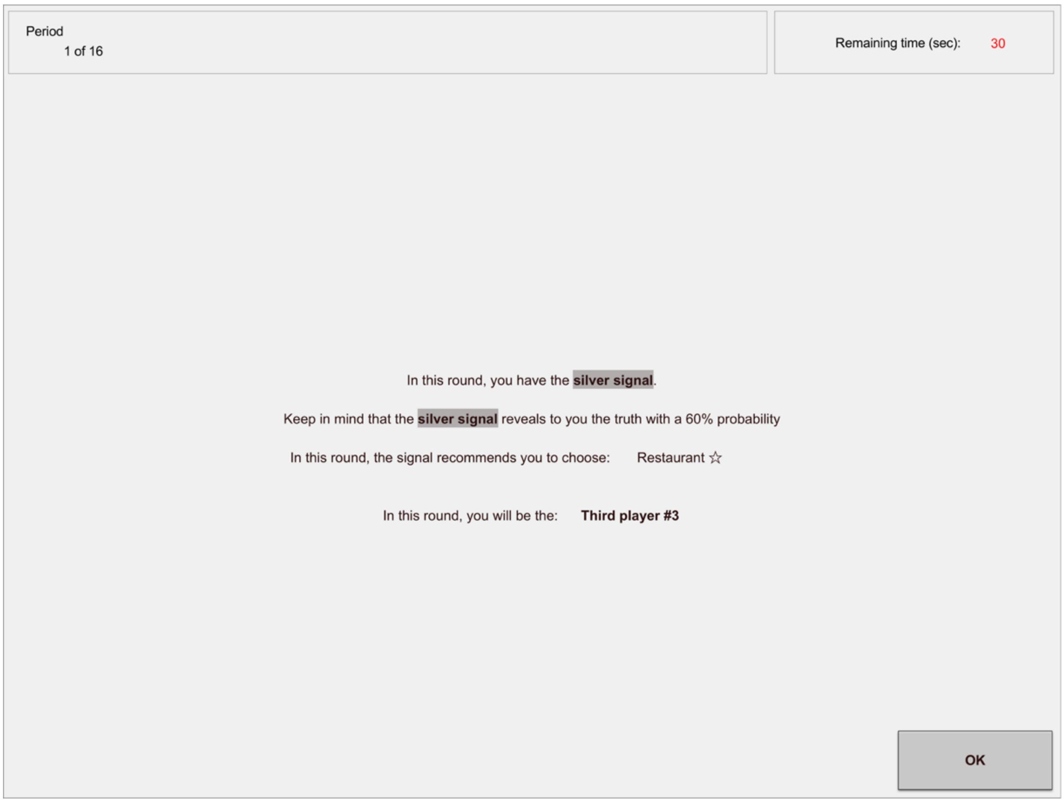


Figure 21 – Silver signal screen



As can be seen in both figures, the screen showed participants that the signal was a recommendation of which restaurant could be the good one, and it also repeated the probability of these signals being correct: 60% for the silver signal and 90% for the gold signal. Next, the decision-making screen was shown to players, and the signal and recommendation were also displayed on this next screen again. These screens can be seen in Figures 22 and 23.

Figure 22 – Decision-making screen with gold signal

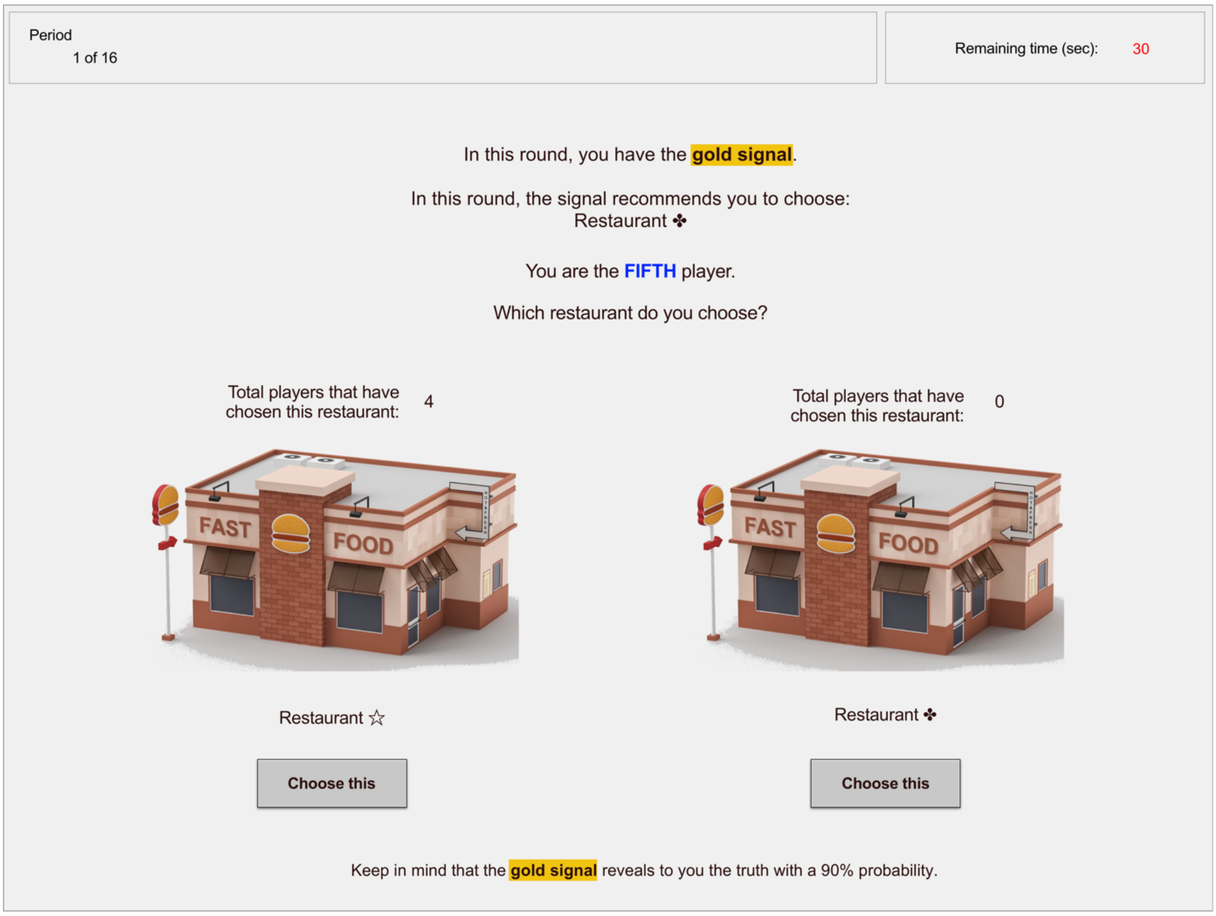
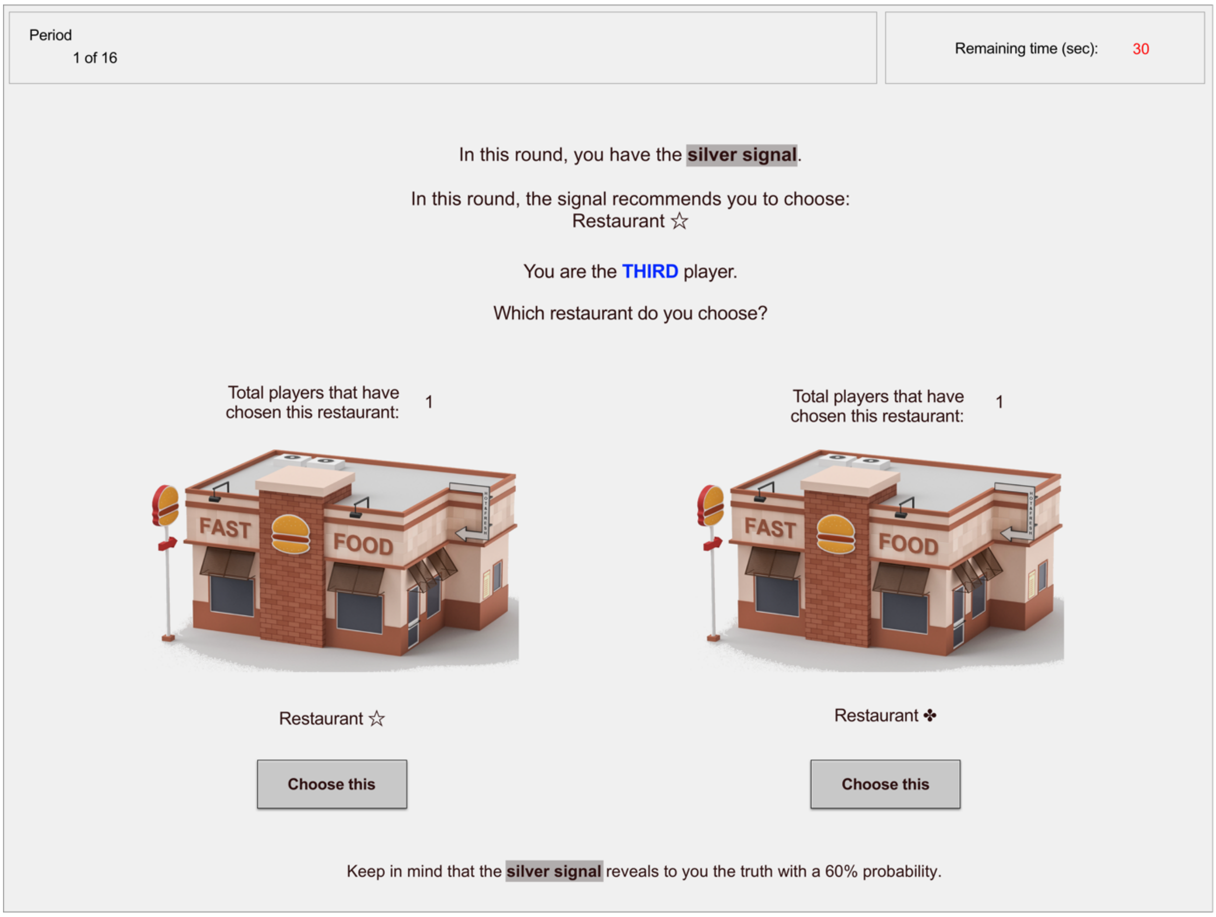


Figure 23 – Decision-making screen with silver signal



So, both images show that players could see the total number of players who had chosen each restaurant and also the signal recommendation at the same time. As in experiment 1, in experiment 2, from round 1 to 10, participants played the non-sequential treatment, and from round 11 to 16, they played the sequential treatment (where they could also see the order of each previous players).

4.4 BEST RESPONSE PROBABILITIES

Regarding both experiments, it is necessary to analyze each scenario given some previously stated conditions to understand which decision could be considered "the best response" to each player on each round. Therefore, the model propositions for each experiment are described in this subsection. The following calculations were done based on the parameters used in the experiment: a total of 6 subjects per group, in which one of the players was more informed than the other five.

In both experiments in this study, it was given that:

Number of players (n) = 6;

1 player is fully informed or more informed;

5 players are uninformed or less informed;

p = strength of the signal received by the less informed players (probability that the signal is correct).

q = strength of the signal received by the more informed player (probability that the signal is correct).

Also, it is important to highlight that $0.5 \leq p \leq q \leq 1$, and on the non-sequential treatment, the sequence of moves was not observed. The benchmark theoretical analysis assumes all players behave rationally.

The first player always has the incentive to follow his own private signal, so the less informed player guesses correctly with probability p and the more informed player with probability q when the scenario is (0,0).

Now, about the second mover's decision-making process. He observes that one person has chosen one option (let's say A), and no one has chosen the other. This is the (1,0) or (0,1) scenario. If the second mover is the more informed player, he clearly has an incentive to follow his own signal, because the stronger signal is always the most accurate one. But what if the second mover is the less informed player? The reasoning works as follows: an uninformed second mover knows that there was a 1/5 probability that the first mover was informed, followed his own signal and chose correctly with probability q. With probability 4/5, the first mover was one of the less informed ones, followed his own signal and chose correctly with probability p. Therefore, the probability that a random first mover made the correct choice is (4/5*p + 1/5*q). Since this probability is always higher than p, a less informed second mover always has an incentive to ignore his own private signal and follow the majority. A similar, although more cumbersome process, shows that when the majority is unanimous, less informed players always have an incentive to follow the herd, regardless of the signal they received.

That being said, the general probabilities for each scenario[1] of the majority wisdom are given by:

If the scenario is (1,0) or (0,1), the majority is right with probability:

$$\frac{4p+q}{5} \tag{4}$$

[1] Scenarios are noted as:
(number of players that had chosen Restaurant ☆, number of players that had chosen Restaurant ✤), e.g.: (2,0)

If the scenario is (2,0) or (0,2), the majority is right with probability:

$$\frac{3p+q+pq}{5-p-q+2pq} \tag{5}$$

If the scenario is (3,0) or (0,3), the majority is right with probability:

$$\frac{2p+q+2pq}{5-2p-2q+4pq} \tag{6}$$

If the scenario is (4,0) or (0,4), the majority is right with probability:

$$\frac{p+q+3pq}{5-3p-3q+6pq} \tag{7}$$

If the scenario is (5,0) or (0,5), the majority is right with probability:

$$\frac{q+4pq}{5-4p-4q+8pq} \tag{8}$$

The wisdom of the minority happens when the majority is not unanimous. Let's consider a less informed fourth mover observing a situation where 2 players chose one of the options (say A) and 1 player chose the other: this is the (2,1) scenario. The fourth mover reasons as follows:

The possible combinations of the first three movers are:

1. more informed, less informed, less informed;
2. less informed, more informed, less informed;
3. less informed, less informed, more informed;
4. less informed, less informed, less informed.

The first and last combinations can never generate a (2,1) scenario, since in both cases, the less informed players will always follow the herd. The other two combinations can generate a (2,1) scenario.

In the (less informed, more informed, less informed) case (alternative 2), there are three possible ways of getting (2,1) or (1,2). In the (less informed, less informed, more informed) case (alternative 3), there are also three possible ways of getting (2,1) or (1,2.)

All 6 possible paths generating (2,1) or (1,2) are highlighted in the picture in Appendix E, with their respective probabilities (assuming that option A is the correct one). It was found the probability of each of these cases, added them all up, and found what percentage of this total is composed of wise minorities. The expressions found were reported in this subsection.

Likewise, the general probabilities for each scenario of the minority wisdom are given by:

If the scenario is (2,1) or (1,2), the minority is right with probability:

$$\frac{(1-p)(p+2q-2pq)}{2(p+q-2pq)} \tag{9}$$

If the scenario is (3,1) or (1,3), the minority is right with probability:

$$\frac{(1-p)q}{(1-p)q+p(1-q)} \tag{10}$$

If the scenario is (4,1) or (1,4), the minority is right with probability:

$$\frac{(1-p)q}{(1-p)q+p(1-q)} \tag{11}$$

If the scenario is (3,2) or (2,3), the minority is right with probability:

$$\frac{\begin{pmatrix} p(1-p)(1-q)+p^2(1-p)(1-q)+p(1-p)^2(1-q)+ \\ (1-p)q+(1-p)^2q+p(1-p)^2+(1-p)^3q \end{pmatrix}}{\begin{pmatrix} p(1-p)(1-q)+p^2(1-p)(1-q)+p(1-p)^2(1-q)+(1-p)q+(1-p)^2q+p(1-p)^2+ \\ (1-p)^3q+p(1-q)+p^2(1-q)+p^3(1-q)+pq(1-p)+p^2q(1-p)+pq(1-p)^2 \end{pmatrix}} \tag{12}$$

Therefore, for the experiment 1 (also called from now on as Case 1), which has $p = 0.5$ and $q = 1.0$, it can be calculated that:

If the scenario is (1,0) or (0,1), the majority is right with probability 0.60;

If the scenario is (2,0) or (0,2), the majority is right with probability 0.786.

If the scenario is (3,0) or (0,3), the majority is right with probability 0.9286.

If the scenario is (4,0) or (0,4), the majority is right with probability 0.9848.

If the scenario is (5,0) or (0,5), the majority is right with probability 1.

Thus, larger (unanimous) majorities are more likely to be right.

If the scenario is (2,1) or (1,2), the minority is right with probability 0.75.

If the scenario is (3,1) or (1,3), the minority is right with probability 1.

If the scenario is (4,1) or (1,4), the minority is right with probability 1.

If the scenario is (3,2) or (2,3), the minority is right with probability 0.67.

Consequently, the order of increasing minority wisdom is (3,2), (2,1), (3,1 and 4,1).

Next, experiment 2 has p = 0.60 and q = 0.90, which is also:

p = strength of the silver signal;

q = strength of the gold signal.

So, using the same general probabilities formula, it can be found that, for majority wisdom:

If the scenario is (1,0) or (0,1), the majority is right with probability 0.66.

If the scenario is (2,0) or (0,2), the majority is right with probability 0.707.

If the scenario is (3,0) or (0,3), the majority is right with probability 0.764.

If the scenario is (4,0) or (0,4), the majority is right with probability 0.834.

If the scenario is (5,0) or (0,5), the majority is right with probability 0.922.

And the probabilities for the minority wisdom are:

If the scenario is (2,1) or (1,2), the minority is right with probability 0.628.

If the scenario is (3,1) or (1,3), the minority is right with probability 0.857.

If the scenario is (4,1) or (1,4), the minority is right with probability 0.857.

If the scenario is (3,2) or (2,3), the minority is right with probability 0.556.

So, the analysis goes in a way that:

Player 1: follows own signal (regardless of whether it is silver or gold).

Player 2: if silver signal, ignore signal and follow majority. If gold signal, follow own signal.

The fact that player 2 with a silver signal ignores the signal and follows the majority means that he will not add information to subsequent players. From now on, if there is a unanimous majority (2,0, 3,0, 4,0 or 5,0), a player with a silver signal always ignores his own signal and follows the majority.

Whenever there is a tie (1,1 or 2,2), the next player always follows his own signal (regardless of whether it is silver or gold). This means that a player will choose correctly when there is a tie not with a 0.5 probability, but with a probability of either p or q (depending on whether the player is silver or gold).

A gold player always follows his own signals, regardless of the score.

If the score is (2,1), (3,1), or (4,1), silver players follow the minority (as long as p and q are sufficiently different). Gold players don't (they always follow their own signal). The wisdom of the minority when it is (2,1) or (1,2) is just slightly higher than the silver signal (62.8% versus 60%). If the silver signal tells to go against the minority, players still have an incentive to ignore it and follow the minority, but the difference is minimal.

If the score is (3,2), silver players might or might not follow the minority. The minority is more likely to be right than the majority when the score is (3,2) or (2,3) (55.6% chance). However, this probability is lower than the accuracy of the silver signal we are considering

(60%). This means if a participant is the sixth player and encounters the score (3,2), given that *$p = 0.60$*, silver players did not have an incentive to follow the minority when the signal contradicts it. According to the math explained above, they had an incentive to follow the signal they received.

4.5 HYPOTHESIS DEVELOPMENT

Combining the theoretical gap previously explained in Chapter 3 with the research goal, more precisely, the specific goals, some hypotheses were developed to be tested by the proposed experiments. They are as follows:

H1: Subjects are less likely to realize when their best course of action is to follow the minority;

H2: Subjects always act rationally;

H3: Which behavior pattern arises from subjects that deviate from the best response?

- **H3.A**: When subjects deviate from the best response they follow the majority;
- **H3.B**: When subjects deviate from the best response they follow the minority;
- **H3.C**: When subjects deviate from the best response they choose randomly;

H4: There is a moderation relationship between the unanimity of the majority, the kind of signal, and the best response;

H5: Subjects learn over time;

H6: Majority unanimity size influences subjects' decision-making;

H7: Cognitive reflection skills are related to rationality in decision-making;

H8: Time spent on decision-making influence its outcome;

H9: Subjects' behavior differs between genders;

H10: Subjects' educational level influences decision-making;

H11: Subjects' age influences decision-making;

4.6 CONSTITUTIVE AND OPERATIONAL DEFINITION OF VARIABLES

To better elucidate the meaning of each used variable, the concepts attributed to the variables were listed, according to their constitutive definition (CD) and operational definition (OD) as well as the literature on which the choice of the variable was based.

a) Cognitive reflection test:

CD: a measurement of cognitive ability. According to Frederick (2005b, p. 26) CRT scores "are predictive of the types of choices that feature prominently in tests of decision-making theories, like expected utility theory and prospect theory. [...] [The] relation is sometimes so strong that the preferences themselves effectively function as expressions of cognitive ability".

OD: subject individual score for the CRT applied on stage 2 in both experiments.

b) Duration:

OD: time in seconds each player took to make a decision on each stage.

c) Age:

OD: subjects' age measured in years.

d) Marital status:

OD: subjects' current marital status they answered in the social demographic questionnaire.

e) Education level:

OD: subjects highest achieved educational level they answered in the social demographic questionnaire.

f) Income:

OD: subjects' personal income on last year according to answers in the social demographic questionnaire.

g) Employment:

OD: subjects' current employment status they answered in the social demographic questionnaire.

h) Gender:

OD: binary variable that is given 0 whenever the participant's gender is female and 1 whenever the participant's gender is male.

Logistic regressions were used to analyze the data. This kind of regression tries to estimate the probability of occurrence of a phenomenon. It is also called as binary logistic regression (Favero & Belfiore, 2017). The data analyzed constituted a panel with a temporal evolution of 16 periods (rounds) for each subject. The general expression for a panel logistic regression that presents itself in a dichotomic way is given by:

$$p_i = \frac{e^{(\alpha+\beta_1 X_{1it}+\beta_2 X_{2it}+\cdots+\beta_k X_{kit})}}{1+e^{(\alpha+\beta_1 X_{1it}+\beta_2 X_{2it}+\cdots+\beta_k X_{kit})}} \tag{13}$$

So, the logit which parameters the study tried to estimate was defined by:

$$Z_i = \alpha + \beta_1 . CRT_{it} + \beta_2 . t + \beta_3 . D_{non-unanimous_{it}} + \beta_k . \delta_{it} \quad (14)$$

Consequently, the logistic regression used to analyze experiment 1 was given by:

$$p_i = \frac{e^{(\alpha+\beta_1 . CRT_{it}+\beta_2 . t+\beta_3 . D_{non-unanimous_{it}}+\beta_k . \delta_{it})}}{1+e^{(\alpha+\beta_1 . CRT_{it}+\beta_2 . t+\beta_3 . D_{non-unanimous_{it}}+\beta_k . \delta_{it})}} \quad (15)$$

Where:

The dichotomous variable is named *rational*, which is given by 1 when subjects chose the best response given the scenario presented to them on each round or given by 0 when they chose the other alternative. That is, in experiment 1, subjects were designated 1: (a) when they followed the information received (when the participant was an informed player in that round); (b) when they followed the unanimous majority scenarios ((1,0), (2,0), (3,0), (4,0) or (5,0)); (c) when they followed the minority on non-unanimous majorities scenarios ((2,1), (3,1), (4,1), (3,2)). The best response is characterized by the alternative which gives the player a higher probability of choosing the good restaurant/correct answer. The probabilities were stated in subsection 4.4.

CRT_i: subject individual score for the CRT applied on stage 2;

t: is the number of the round;

$D_{non\text{-}unanimous}$: is a dummy variable for subject *i* on round *t*, that is given by 0 when subjects faced a unanimous majority scenario (from now on also referred as UMS): ((1,0), (2,0), (3,0), (4,0) or (5,0)); or given by 1 when subjects faced a non-unanimous majority scenario (from now on also referred as non-UMS);

δ_{it}: is a control variables vector for subject *i* for all *t* rounds. They are as follows: *age, marital, education, employment, income, duration, diff majority*.

Diff majority: reflects the difference of players between the unanimous choice in each scenario. It is given as 1 for scenarios (1,0) or (0,1), given as 2 for scenarios (2,0) or (0,2) and so on.

For experiment 2, it was added later a dummy variable called *gold info*, which was given as 1 when participants received the gold signal in that round and was given as 0 when participants received the silver signal in that round. That being said, the logit which parameters it was tried to estimate was defined by:

$$Z_i = \alpha + \beta_1 . CRT_{it} + \beta_2 . t + \beta_3 . D_{non-unanimous_{it}} + \beta_4 . D_{gold_{it}} + \beta_k . \delta_{it} \quad (16)$$

Consequently, the logistic regression used to analyze was given by:

$$p_i = \frac{e^{(\alpha+\beta_1 . CRT_{it}+\beta_2 . t+\beta_3 . D_{non-unanimous_{it}}+\beta_4 . D_{gold_{it}}+\beta_k . \delta_{it})}}{1+e^{(\alpha+\beta_1 . CRT_{it}+\beta_2 . t+\beta_3 . D_{non-unanimous_{it}}+\beta_4 . D_{gold_{it}}+\beta_k . \delta_{it})}} \quad (17)$$

Also, in experiment 2, regarding the moderation hypothesis test, an interaction term was added between an independent variable (*t*) and its moderator (*gold*) for a two-way interaction effect analysis (Aiken & West, 1991; Dawson, 2014b; Hayes, 2013). In this way, it was possible to test the moderation between the kind of signal and the subjects learning process across time (rounds).

So, the logit which parameters it was tried to estimate was given by:

$$Z_i = \alpha + \beta_1 . CRT_{it} + \beta_2 . t + \beta_3 . D_{non-unanimous_{it}} + \beta_4 . D_{gold_{it}} + \beta_5 . (t \times D_{gold_{it}}) + \beta_k . \delta_{it} \tag{18}$$

Thus, the logistic regression used to analyze was given by:

$$p_i = \frac{e^{(\alpha + \beta_1 . CRT_{it} + \beta_2 . t + \beta_3 . D_{non-unanimous_{it}} + \beta_4 . D_{gold_{it}} + \beta_5 . (t \times D_{gold_{it}}) + \beta_k . \delta_{it})}}{1 + e^{(\alpha + \beta_1 . CRT_{it} + \beta_2 . t + \beta_3 . D_{non-unanimous_{it}} + \beta_4 . D_{gold_{it}} + \beta_5 . (t \times D_{gold_{it}}) + \beta_k . \delta_{it})}} \tag{19}$$

In this analysis, the product term should be statistically significant so the interaction could be interpretable (Dawson, 2014a).

Furthermore, to test a three-way interaction (often analyzed as a relationship between a variable X and dependent variable Y, moderated by variables Z and W (Dawson, 2014a)), new interaction terms were added to understand the relationship between: the rational choice (best response), the kind of signal received, the type of majority presented to players (UMS or non-UMS) and subjects' learning across time (rounds). So, now the logit which parameters it was tried to estimate was given by:

$$\begin{aligned} Z_i = \alpha &+ \beta_1 . CRT_{it} + \beta_2 . t + \beta_3 . D_{non-unanimous_{it}} + \beta_4 . D_{gold_{it}} + \beta_5 . \left(t \times D_{gold_{it}}\right) \\ &+ \beta_6 . \left(t \times D_{non-unanimous_{it}}\right) + \beta_7 . \left(D_{gold_{it}} \times D_{non-unanimous_{it}}\right) \\ &+ \beta_8 . \left(t \times D_{gold_{it}} \times D_{non-unanimous_{it}}\right) + \beta_k . \delta_{it} \end{aligned} \tag{20}$$

Which, consequently, means that the logistic regression used to estimate the parameters was given by:

$$p_i = \frac{e^{\left(\begin{matrix} \alpha + \beta_1 . CRT_{it} + \beta_2 . t + \beta_3 . D_{non-unanimous_{it}} + \beta_4 . D_{gold_{it}} + \beta_5 . \left(t \times D_{gold_{it}}\right) \\ + \beta_6 . \left(t \times D_{non-unanimous_{it}}\right) + \beta_7 . \left(D_{gold_{it}} \times D_{non-unanimous_{it}}\right) \\ + \beta_8 . (t \times D_{gold_{it}} \times D_{non-unanimous_{it}}) + \beta_k . \delta_{it} \end{matrix}\right)}}{1 + e^{\left(\begin{matrix} \alpha + \beta_1 . CRT_{it} + \beta_2 . t + \beta_3 . D_{non-unanimous_{it}} + \beta_4 . D_{gold_{it}} + \beta_5 . \left(t \times D_{gold_{it}}\right) \\ + \beta_6 . \left(t \times D_{non-unanimous_{it}}\right) + \beta_7 . \left(D_{gold_{it}} \times D_{non-unanimous_{it}}\right) \\ + \beta_8 . (t \times D_{gold_{it}} \times D_{non-unanimous_{it}}) + \beta_k . \delta_{it} \end{matrix}\right)}} \tag{21}$$

5 DATA ANALYSIS AND RESULTS

After collecting and processing the gathered data, this chapter presents the statistical procedures with descriptive statistics, normality tests, and regression estimates, as previously mentioned in the methodology chapter.

5.1 DESCRIPTIVE STATISTICS

5.1.1 Experiment 1

Descriptive statistics were calculated, and frequency tables were compiled to best illustrate the gathered data. This information helps to better understand the analyzed sample.

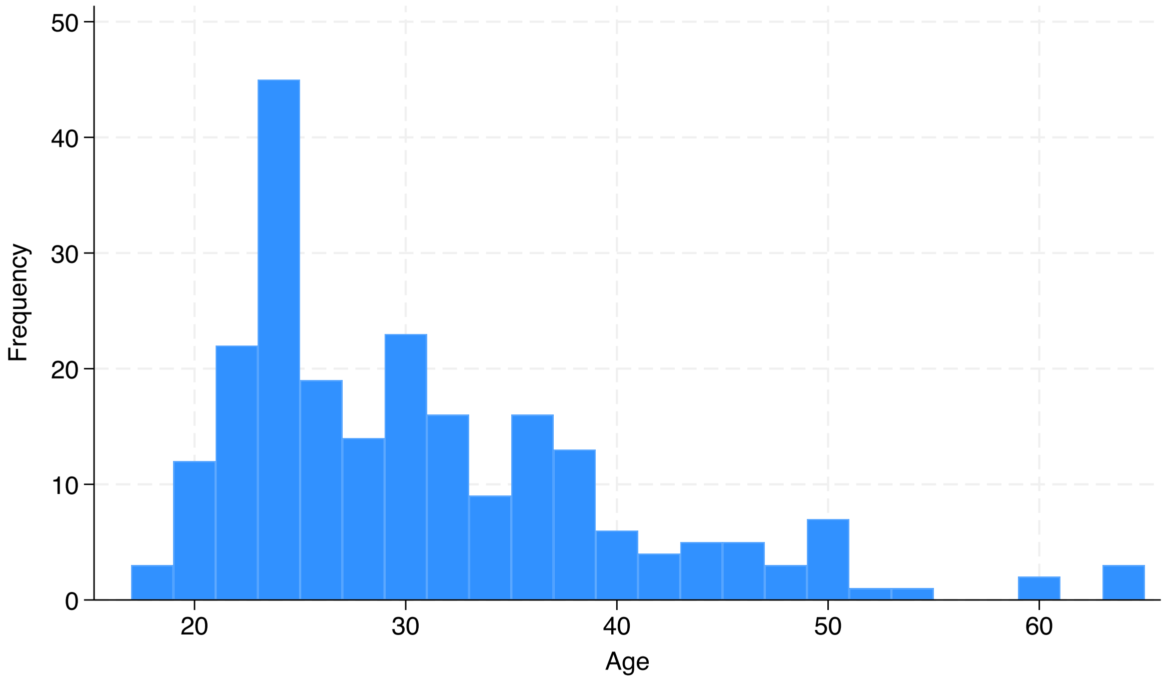
A total of 240 participants were gathered to participate in the experiment 1, however only 229 participations were validated. Some answers were discarded due to incomplete answers or if a participant failed any attention checks. All participants were 18 years old or older and acknowledged their participation in the experiment. The sociodemographic characteristics of the sample have been tabulated and are shown next.

Table 2 – Sample age descriptive statistics: experiment 1

Age	**Female**	**Male**	**Total**
Mean	30.47818	30.5982	30.54148
Standard deviation	9.422096	9.28086	9.352468
Minimum	18	18	18
Maximum	64	64	64
Median	28	29	28
Skewness	1.447034	1.03842	1.252866
Kurtosis	4.926719	3.95299	4.465111
Total	**117**	**112**	**229**

Source: research data, 2024.

Figure 24 – Age histogram: experiment 1



Source: research data, 2024.

It is possible to see that the mean average was around 30 years old, and the sample was composed of approximately 48.9% by male gender and 51.1% by female gender. The Shapiro Wilk-test was performed for normal data and the result was $Z = 6.702$, *p-value* = 0.0001, which means data did not follow normal distribution. There were not many differences between genders about the descriptive statistics as seen on table 2 according to two-sample Mann-Whitney (MH) test: *p-value*: 0.8563.

Table 3 – Educational level by gender: experiment 1

Educational level	**Female**		**Male**		**Total**	
	Obs.	**%**	**Obs.**	**%**	**Obs.**	**%**
Some high school	2	1.7%	3	2.7%	5	2.2%
Complete High school	21	17.9%	22	19.6%	43	18.8%
Some bachelor’s degree	21	17.9%	23	20.5%	44	19.2%
Bachelor’s degree	52	44.4%	45	40.2%	97	42.4%
Master’s or Ph.D. degree	21	17.9%	19	17.0%	40	17.5%
Total	**117**		**112**		**229**	

Source: research data, 2024.

As shown in Table 3, it is possible to see that most of the sample were people who had finished college: approximately 44.4% of female players and 40.2% of male players. That was somewhat expected as research was conducted online but in a university environment. There were no such differences in educational level between genders according to MH test: *p-value* = 0.4890. Next, tables 4 and 5 show the ethnic and marital status of the analyzed sample by gender.

Table 4 – Ethnicity by gender: experiment 1

Ethnic group	Female		Male		Total	
	Obs.	**%**	**Obs.**	**%**	**Obs.**	**%**
White	63	55.3%	62	57.9%	125	56.6%
Black or African American	29	25.4%	22	20.6%	51	23.1%
Indigenous	0	0%	1	0.9%	1	0.5%
Asian	14	12.3%	15	14.0%	29	13.1%
Other	8	7.0%	7	6.5%	15	6.8%
Total	**117**		**112**		**229**	

Source: research data, 2024.

Table 5 – Marital status by gender: experiment 1

Marital status	Female		Male		Total	
	Obs.	**%**	**Obs.**	**%**	**Obs.**	**%**
Single (never married)	60	51.3%	75	67.0%	135	59.0%
Living with a partner	15	12.8%	13	11.6%	28	12.2%
Married	36	30.8%	19	17.0%	55	24.0%
Widowed	0	0%	0	0.0%	0	0.0%
Divorced	6	5.1%	5	4.5%	11	4.8%
Total	**117**		**112**		**229**	

Source: research data, 2024.

Analyzing Tables 4 and 5, it is possible to see that, regarding ethnicity, more than 50% of participants were white (56.6%), and the second larger group were black or African American participants (23.1%). There were no such differences between genders according to Fisher's exact test: *p-value* = 0.843. Regarding the marital status of participants, more than half of them were single (59%). As same as ethnicity, there were no such differences at a 5% level of significance between genders according to Pearson's Chi-square test: *p-value* = 0.070.

Further, on the sociodemographic questionnaire, participants were asked about their current employment status and their personal income. The results by gender are as follows in Tables 6 and 7.

Table 6 – Employment status by gender: experiment 1

Employment status	Female		Male		Total	
	Obs.	%	Obs.	%	Obs.	%
Full-time	46	39.3%	65	58.0%	111	48.5%
Part-time	36	30.8%	15	13.4%	51	22.3%
Unemployed	34	29.1%	30	26.8%	64	27.9%
Retired	1	0.9%	2	1.8%	3	1.3%
Total	**117**		**112**		**229**	

Source: research data, 2024.

Table 7 – Annual personal income by gender: experiment 1

Annual personal income	Female		Male		Total	
	Obs.	%	Obs.	%	Obs.	%
$0-$9,999	20	17.1%	21	18.8%	41	17.9%
$10,000-$24,999	18	15.4%	15	13.4%	33	14.4%
$25,000-$49,999	31	26.5%	24	21.4%	55	24.0%
$50,000-$74,999	16	13.7%	22	19.6%	38	16.6%
$75,000-$99,999	15	12.8%	11	9.8%	26	11.4%
Above $100,000	8	6.8%	17	15.2%	25	10.9%
Preferred not to answer	9	7.7%	2	1.8%	11	4.8%
Total	**117**		**112**		**229**	

Source: research data, 2024.

Regarding employment status, it is seen in Table 6 that almost half of the participants were full-time employed (48.5%), and less than one-third were unemployed (27.9%). At the level of 5% of significance, there were no such differences between genders according to MH test: *p-value* = 0.535. Regarding the participants' annual personal income, around 24% received between $25,000 and $49,000 last year. As with employment status, personal income did not show significant differences between genders: MH test: *p-value* = 0.8695.

Each participant was paid $0.50 per correct answer and $2 as a participation fee. The descriptive statistics for participants' earnings are listed below.

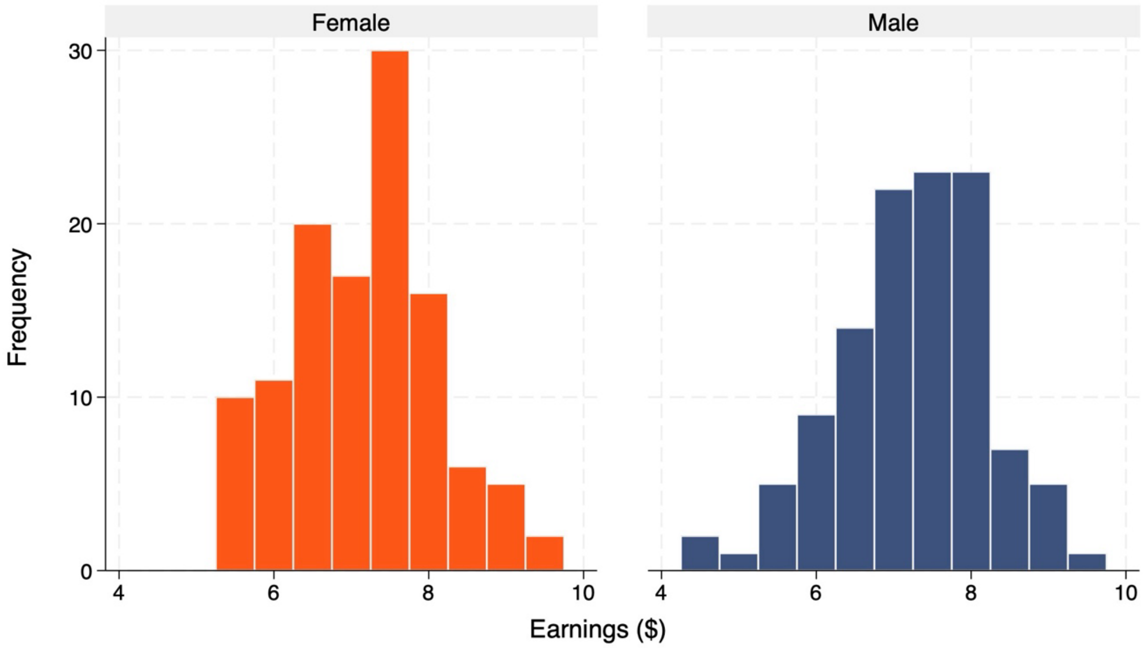
Table 8 – Players' earnings by gender: experiment 1

Age	Female	Male	Total
Mean	7.1624	7.2411	7.2009
Standard deviation	0.9510	0.9702	0.9592
Minimum	5.50	4.50	4.50
Maximum	9.50	9.50	9.50
Median	7.50	7.50	7.50
Skewness	0.1248	-0.3851	-0.1296
Kurtosis	2.5992	3.1690	2.8482
Observations	**117**	**112**	**229**

Source: research data, 2024.

About normality of earnings, according to the Shapiro-Wilk test for normal data: *p-value* = 0.95237*,* which means participants' earnings fit normal data. When comparing earnings between genders, there was a statistical difference at the 5% level of significance, according to the two-sample Z test: p-value = 0.0173. On average, each male participant received $7.24, and each female participant received $7.16. The earnings histogram can be seen in Figure 25.

Figure 25 – Players' earning histogram by gender: experiment 1



Source: research data, 2024.

At last, about the CRT applied at the end of experiment 1, participants could have answered right from 0 to 3 times. According to the SW test, the results fitted normal data: *p-value* = 0.3898. When comparing the results between genders, there was no statistical difference according to the two-sample Z test: *p-value* = 0.5277. CRT correct answers by gender are listed below in Table 9.

Table 9 – CRT correct answers by gender: experiment 1

Number of correct answers	**Female**		**Male**		**Total**	
	Obs.	**%**	**Obs.**	**%**	**Obs.**	**%**
0	35	29.9%	29	25.9%	64	27.9%
1	21	17.9%	19	17.0%	40	17.5%
2	32	27.4%	37	33.0%	69	30.1%
3	29	24.8%	27	24.1%	56	24.5%
Total	**117**		**112**		**229**	

Source: research data, 2024.

So, there were a total of 3.644 answers available for analysis. In all these rounds, players had the information 583 times (approximately 0.159, which adhered to the probability f = 1/6 of being an informed subject in each round).

However, the main analysis presented in this study concerns the non-sequential treatment, that is, the first 10 rounds. So, the analysis will be based on the 2.290 available answers from the first treatment. Participants in this treatment received the correct information 380 times (approximately 0.16) and followed these instructions 97.6% of the time.

The next filter was to remove the rounds where there was a tie. Whenever a tie happened and players were uninformed, there was no choice but to choose randomly. Next, the players that received the information were removed. So, the analysis from now on was based only on answers that players did not have answers, and it was not a tie, which ended up with 1.438 answers. From those answers, players chose the best response 58.7% of the time (877) and deviated from it 41.3% of the time (594). Also, it was observed that they followed the majority 70.2% of the time and the minority 29.8% of the time. Combining these possibilities, table 10 shows a summary of these choices.

Table 10 – Players' behavior: experiment 1

Players' behavior	**Majority**	**Minority**	**Total**
Followed best response	46.2%	12.4%	58.7%
Deviated from best response	24.4%	17.3%	41.3%
Total	**70.2%**	**29.8%**	**100%**

Source: research data, 2024.

As shown in Table 10, it is possible to see that approximately 70% of the time, players chose to follow the majority, regardless of the best option. From that amount, it can be calculated that 65.8% of majority choices were following the best response strategy. The same can be calculated for players that followed the minority: from the 29.8% that players chose to follow the minority, they were following the best response only in 41.8% of cases. At first analysis, it can be seen that players found it harder to realize when their best strategy was to follow the minority. Later, this idea will be explored deeper in the logistic regressions.

5.1.2 Experiment 2

Similar to the first experiment, this subsection presents the descriptive statistics and frequency tables to help better understand the gathered data and the analyzed sample.

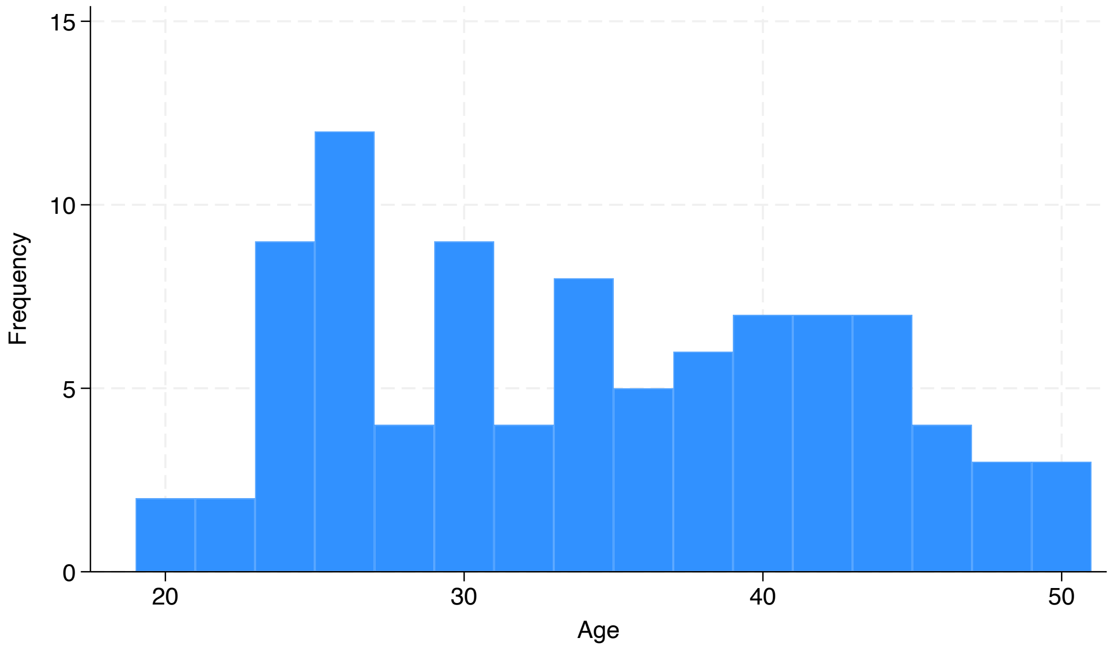
A total of 96 players participated in experiment 2, although only 92 of them could be validated. Four answers had to be discarded due to attention check failure or incomplete answers. All participants were 18 years old or older and acknowledged their participation in the experiment. The sociodemographic characteristics of the sample, which have been tabulated, are shown next.

Table 11 – Sample age descriptive statistics: experiment 2

Age	Female	Male	Total
Mean	33.5227	34.1667	33.8587
Standard deviation	7.6569	8.7113	8.1855
Minimum	20	20	20
Maximum	49	50	50
Median	33	34	33
Skewness	0.1962	0.1249	0.1680
Kurtosis	2.0589	1.7003	1.8597
Total	44	48	92

Source: research data, 2024.

Figure 26 – Age histogram: experiment 2



Source: research data, 2024.

It was possible to see that the mean age was around 33 years old, and the sample was composed of approximately 47.8% of participants of female gender and 52.2% of male gender players. Shapiro Wilk-test was performed for normal data and the result was $Z = 2.512$, *p-value* = 0.006, which means the data did not follow normal distribution. There were not many differences between genders in the descriptive statistics, as seen in Table 11 and according to the MH test: *p-value*: 0.7722.

Table 12 – Educational level by gender: experiment 2

Educational level	**Female**		**Male**		**Total**	
	Obs.	**%**	**Obs.**	**%**	**Obs.**	**%**
Some high school	3	6.8%	0	0%	3	3.3%
Complete High school	8	18.2%	10	20.8%	18	19.6%
Some bachelor's degree	7	15.9%	6	12.5%	13	14.1%
Bachelor's degree	18	40.9%	24	50.0%	42	45.7%
Master's or Ph.D. degree	8	18.2%	8	16.7%	16	17.4%
Total	44		48		92	

Source: research data, 2024.

Similar to the first experiment, in experiment 2, most participants had a bachelor's degree: around 40.9% of female participants and half of male participants (50%). Following the MH test (p-value = 0.5728), there was no statistical difference between genders. Tables 13 and 14 show the ethnic and marital status of the analyzed sample by gender.

Table 13 – Ethnicity by gender: experiment 2

Ethnic group	**Female**		**Male**		**Total**	
	Obs.	**%**	**Obs.**	**%**	**Obs.**	**%**
White	21	47.7%	28	58.3%	49	53.3%
Black or African American	13	29.5%	7	14.6%	20	21.7%
Indigenous	1	2.3%	1	2.1%	2	2.2%
Asian	4	9.1%	8	16.7%	12	13.0%
Other	5	11.4%	4	8.3%	9	9.8%
Total	44		48		92	

Source: research data, 2024.

Table 14 – Marital status by gender: experiment 2

Marital status	Female		Male		Total	
	Obs.	**%**	**Obs.**	**%**	**Obs.**	**%**
Single (never married)	22	50.0%	19	39.6%	41	44.6%
Living with a partner	4	9.1%	7	14.6%	11	12.0%
Married	17	38.6%	15	31.3%	32	34.8%
Widowed	0	0.0%	2	4.2%	2	2.2%
Divorced	1	2,3%	5	10.4%	6	6.5%
Total	**44**		**48**		**92**	

Source: research data, 2024.

According to Table 13, more than half of the participants were white (53.3%), and the second largest group was African American participants (21.7%), which is really similar to the sample of experiment 1. There were no such differences between genders according to Fisher's exact test: *p-value* = 0.359. Observing the marital status of players, half of the females were single (50%), and 39.6% were single male participants. In this sample, there were two widowed participants that Experiment 1 did not have. As same as ethnicity, there were no such differences between genders according to Fisher's exact test: *p-value* = 0.252.

On the sociodemographic questionnaire, participants were also asked about their current employment status and personal income. The results by gender are as follows in Tables 15 and 16.

Table 15 – Employment status by gender: experiment 2

Employment status	Female		Male		Total	
	Obs.	**%**	**Obs.**	**%**	**Obs.**	**%**
Full-time	27	61.4%	22	45.8%	49	53.3%
Part-time	10	22.7%	14	29.2%	24	26.1%
Unemployed	7	15.9%	12	25.0%	19	20.7%
Retired	0	0%	0	0%	0	0.0%
Total	44		48		92	

Source: research data, 2024.

Table 16 – Annual personal income by gender: experiment 2

Annual personal income	**Female**		**Male**		**Total**	
	Obs.	**%**	**Obs.**	**%**	**Obs.**	**%**
$0-$9,999	6	13.6%	10	20.8%	16	17.4%
$10,000-$24,999	4	9.1%	7	14.6%	11	12.0%
$25,000-$49,999	10	22.7%	9	18.8%	19	20.7%
$50,000-$74,999	12	27.3%	5	10.4%	17	18.5%
$75,000-$99,999	4	9.1%	7	14.6%	11	12.0%
Above $100,000	6	13.6%	7	14.6%	13	14.1%
Preferred not to answer	2	4.5%	3	6.3%	5	5.4%
Total	44		48		92	

Source: research data, 2024.

Regarding employment status, Table 15 shows that more than half of the participants were employed full-time (53.3%), with a slight difference between genders: 61.4% of females vs. 45.8% of male participants. It is worth highlighting that there were no retired participants in this sample, as there were a few in Experiment 1. There were no statistical differences between genders according to MH test: *p-value* = 0.1456. About the participant's annual personal income, nearly 21% received between $25,000 and $49,000 last year. The larger portion of female participants (27.3%) received between $50,000 and $74,999 meanwhile the larger portion of male participants (20.8%) received $9,999 or less. However, there were no statistical difference between genders according to the MH test: *p-value* = 0.6096.

Following the first experiment, for each participant of experiment 2 it was paid a $0.50 per correct answer and $2 as a participation fee. The descriptive statistics for participants' earnings are listed below.

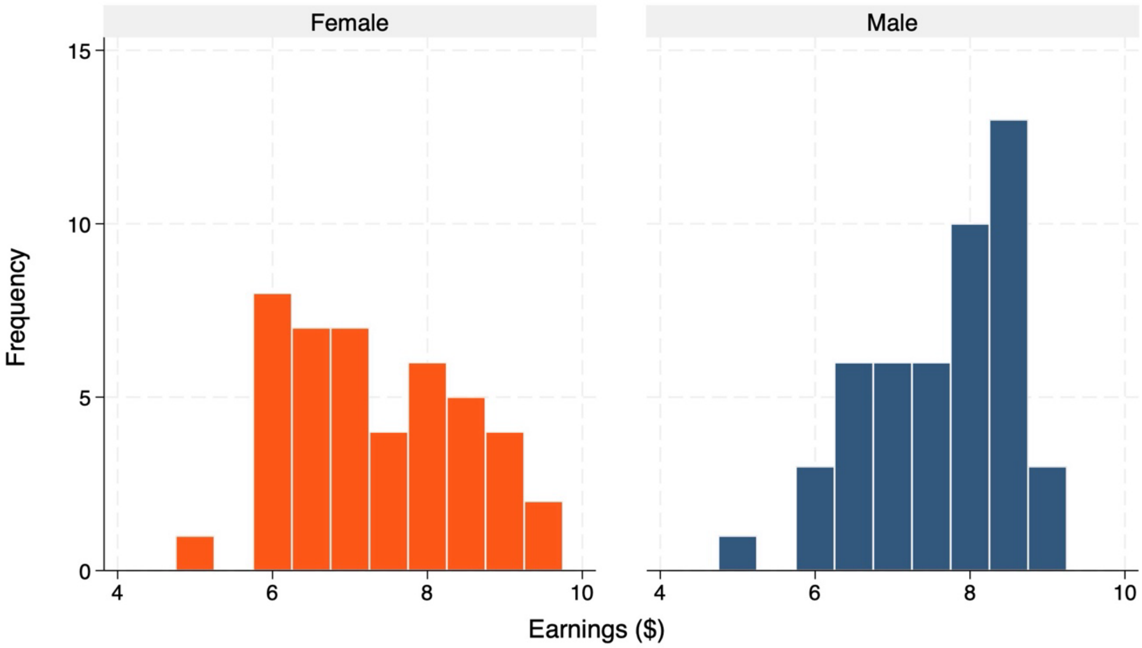
Table 17 – Players' earnings by gender: experiment 2

Age	**Female**	**Male**	**Total**
Mean	7.3409	7.6354	7.4946
Standard deviation	1.1349	0.9438	1.0443
Minimum	5.00	5.00	5.00
Maximum	9.50	9.00	9.50
Median	7.00	8.00	7.50
Skewness	0.1828	-0.6458	-0.2111
Kurtosis	2.0570	2.6968	2.1816
Observations	**44**	**48**	**92**

Source: research data, 2024.

About normality of earnings, according to the Shapiro-Wilk test: *p-value* = 0.2116 participants' earnings fit normal distribution. When comparing earnings between genders, there was a statistical difference according to the two-sample Z test: *p-value* = 0.1582. Each female participant received, on average, $7.34, and each male participant $7.63. Participant's earnings histogram can be seen in Figure 27.

Figure 27 – Players' earning histogram by gender: experiment 2



Source: research data, 2024.

Finally, about the CRT applied at the end of experiment 2, participants could have answered right from 0 to 3 times. According to the SW test, the results fitted normal data: *p-value* = 0.26635. When tested earnings by participants' gender, both data fitted normal data still (female participants' earnings MH test *p-value* = 0.05591 and male participants' earnings MH test *p-value* = 0.90138). When comparing the results between genders, there was no statistical difference according to the two-sample Z test: *p-value* = 0.1569. CRT correct answers by gender are listed below in Table 18.

Table 18 – CRT correct answers by gender: experiment 2

Number of correct answers	**Female**		**Male**		**Total**	
	Obs.	**%**	**Obs.**	**%**	**Obs.**	**%**
0	8	18.2%	10	20.8%	18	19.6%
1	6	13.6%	9	18.8%	15	16.3%
2	6	13.6%	12	25.0%	18	19.6%
3	24	54.5%	17	35.4%	41	44.6%
Total	44		48		92	

Source: research data, 2024.

So, there were a total of 1.472 answers available for analysis. In all these rounds, players had the gold signal 251 times (approximately 0.17, which adhered to the probability f = 1/6 of being a better-informed subject in each round).

As in experiment 1, the main analysis presented in this study about experiment 2 is related to the non-sequential treatment, that is, the first 10 rounds. So, the analysis further on will be based on the 920 available answers from the first treatment. Participants in this treatment received the gold signal information 228 times (approximately 0.178), who followed this information 90.2% of the time.

From each kind of signal, there was a best response based on the probabilities stated in subsection 4.4:

a) players that received the gold signal should follow the received signal;
b) players that received the silver signal should:
    a. follow theirs signal whenever that was a tie;
    b. follow the unanimous majority ((1,0), (2,0), (3,0), (4,0), (5,0)) disregarding their received signal;
    c. follow the minority when there was a non-unanimous majority in cases (2,1), (3,1) or (4,1);
    d. follow their private signal when there is a (3,2) scenario.

With that list of scenarios, a table showing the best response adherence by kind of signal received (gold or silver) was elaborated. It is shown in Table 19.

Table 19 – Players' behavior: experiment 2

Players' behavior	Silver signal	Gold signal	Total
Followed best response	63.8%	90.2%	68.5%
Deviated from best response	36.2%	9.8%	31.5%
Total	**82.2%**	**17.8%**	**100%**

Source: research data, 2024.

As shown in Table 10, it is possible to see that approximately 90.2% of the time, players followed the information stated in the gold signal. However, when they received the silver signal, apparently, they found it harder to follow the best response, as seen that only 63.8% actually did it. More analysis will be made in further chapters.

5.2 PLAYERS' BEHAVIOR

To understand players' behavior across each scenario and between rounds, the percentage of people who followed the unanimous majority and the percentage that followed the minority in non-UMS by order of play was analyzed. For experiment 1, the analysis will be based on some assumptions (that actually filtered some answers, as previously said): participants were uninformed, and there was not a tie.

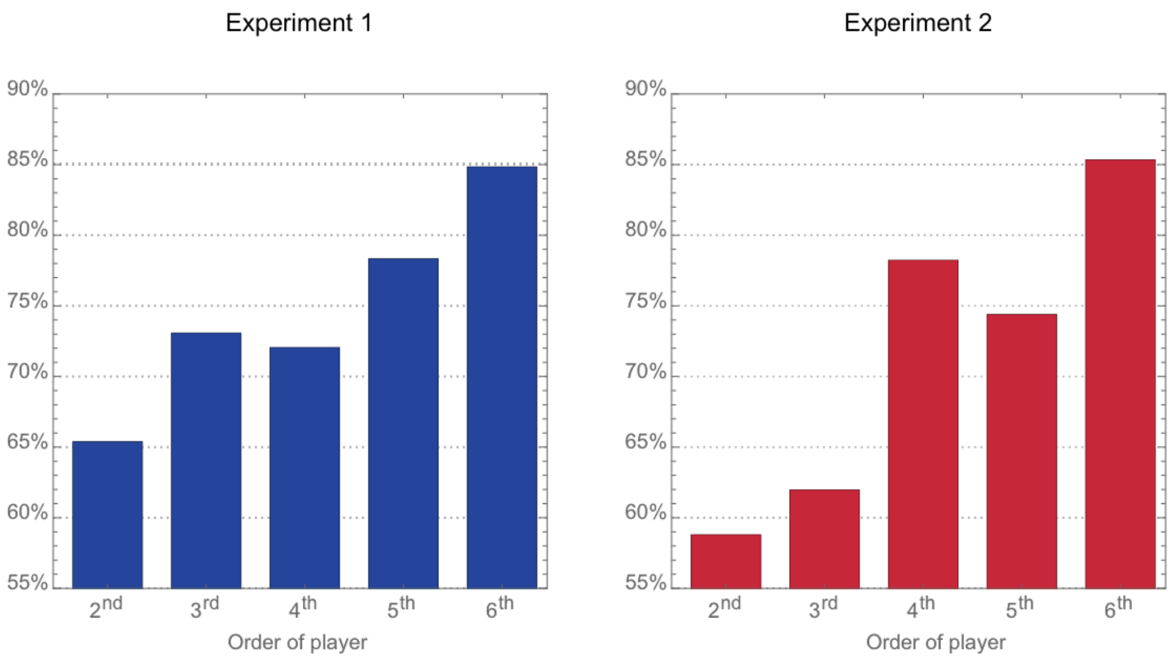
In experiment 1, when there was a UMS, in a general way, players tended to follow this majority more when there was a difference between the number of players inside each restaurant. In experiment 2, looking as well to the less informed players (the ones that received a silver signal), the pattern emerged. This information is summarized in Table 20 and can be seen in Figure 28.

Table 20 – Percentage of players that followed unanimous majority by order of play

	Experiment 1	**Experiment 2**
Order of player	**Uninformed players**	**Silver signal players**
2^{nd} player	65.4%	58.8%
3^{rd} player	73.1%	62.0%
4^{th} player	72.1%	78.3%
5^{th} player	78.4%	74.4%
6^{th} player	84.8%	85.4%

Source: research data, 2024.

Figure 28 – Percentage of players that followed unanimous majority by order of play

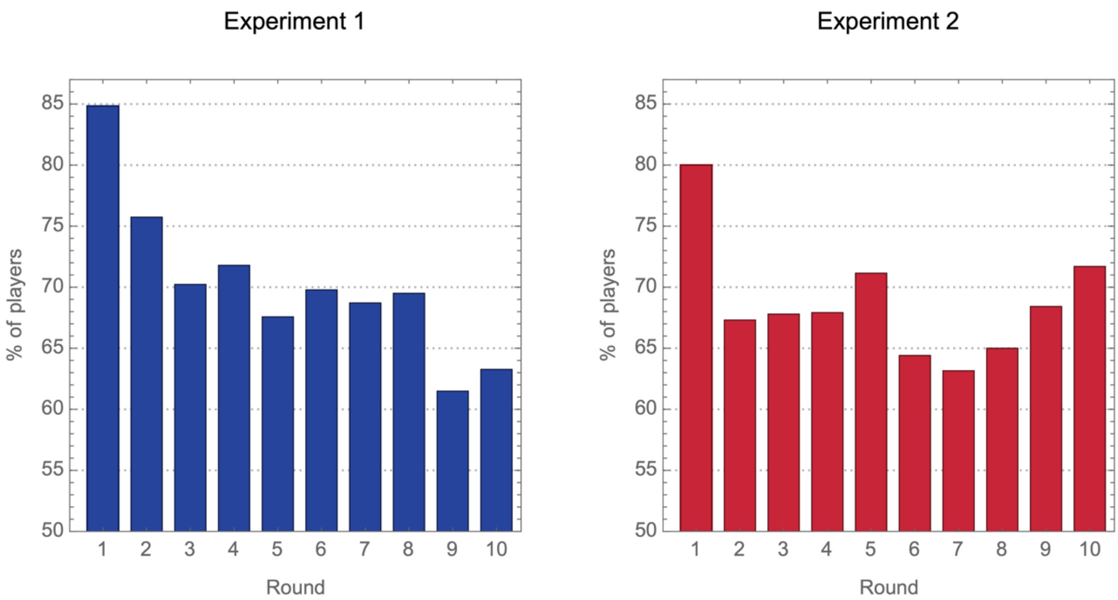


Source: research data, 2024.

As shown above, it can be seen that players followed the unanimous majority 65.4% of the time in experiment 1 and 58.8% of cases in experiment 2 when the players were the 2nd to play (either (1,0) or (0,1). Following the horizontal axis in Figure 28, the larger the unanimous majority was, the higher the probability of a player choosing this same unanimous majority.

The following analysis goes by trying to understand players' behavior across time. For each experiment, it was estimated the percentage of players that had chosen to follow the majority, regardless of it was unanimous or not. For experiment 1, it was analyzed only cases that players did not have the information and there wasn't a tie, and for experiment 2 it was only analyzed cases that weren't a tie, and players had the silver signal. The results can be seen in Figure 29.

Figure 29 – Percentage of players that followed the majority by round

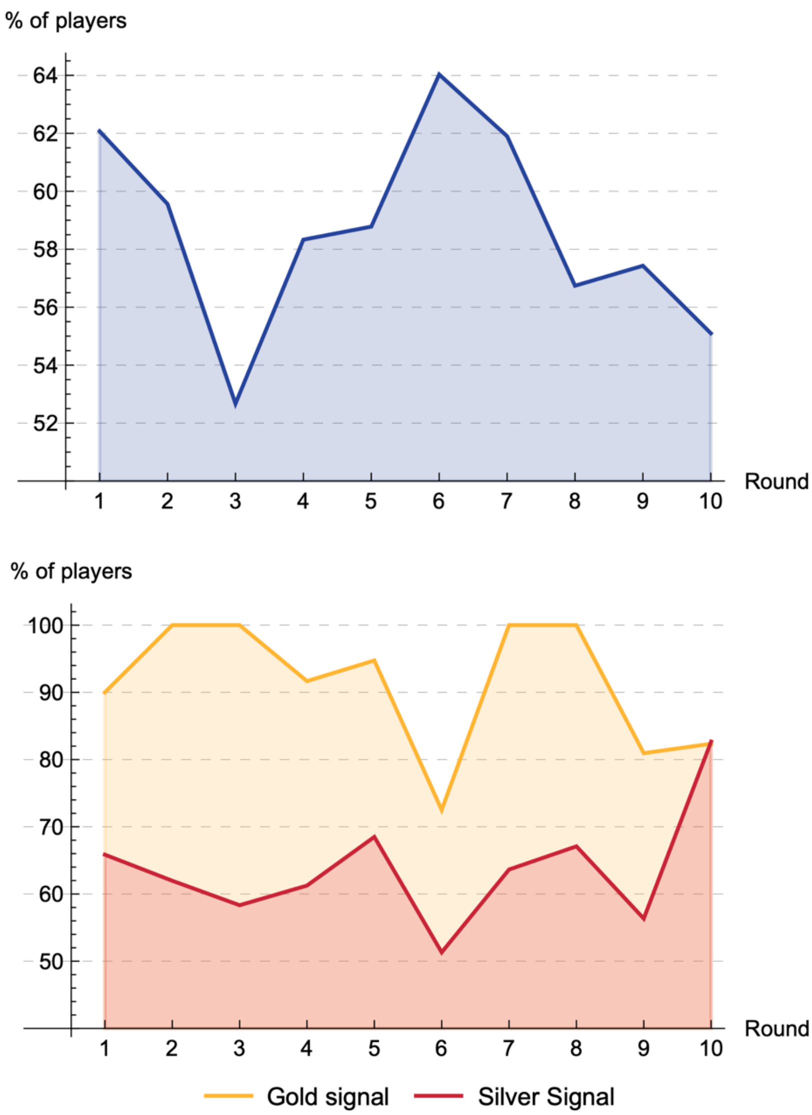


Source: research data, 2024.

Looking at both plots, it appears that across time, players chose the majority with less frequency. That is, players started to either deviate from the unanimous majority or follow a deviator and choose the minority. That behavior is more perceptible in Experiment 1 than in Experiment 2. It looks like players became "majority avoiders." Further analysis will be commented on after logistic regressions.

Next, the analysis follows to understand players' choices regarding their rationality, that is, whether they chose the same option that was the best response for the scenario presented to them or not. For that, it was estimated the percentage of players that had chosen the best response by rounds, which attempted to see any learning pattern across time. For both experiments, it was analyzed cases that were not a tie. For experiment 1, it was only examined cases in which players did not have the information. For experiment 2, the analysis was segmented by the type of signal players had received: gold or silver. The results are shown in Figure 30.

Figure 30 – Players best response percentage by round

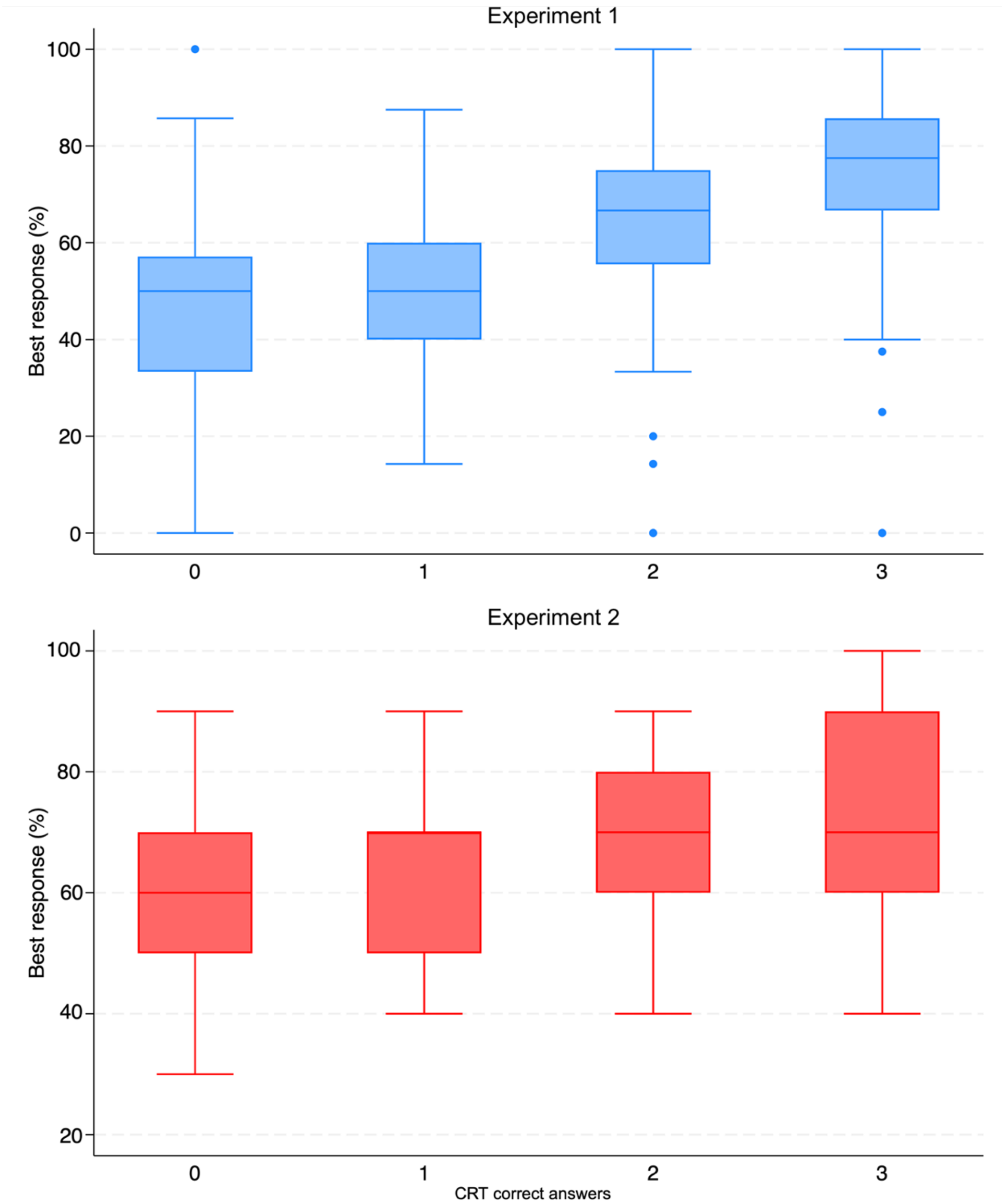


Source: research data, 2024.

Comparing the number of players that followed the best response in each round, it is difficult to see a learning pattern. In experiment 1, it appears that players started to learn after round 6, with around 64% of them following the best response, however the number decreased, on average, until the last round. In experiment 2, players with silver signal followed the best response with a higher percentage rate at the last round, however, there is not a linear growth in the past round. This learning process will be further commented on after logistic regression and moderation analysis.

As previously stated, the cognitive reflection test (CRT) applied at the end of the 16 rounds was an attempt to measure players' cognitive skills. In that way, each player's best response percentage was combined with the number of total answers in the CRT. The mean percentage by experiment can be seen in Table 21. The whole data of both experiments are summarized in two boxplots shown in Figure 31.

Figure 31 – Players' best response by CRT hits boxplot



Source: research data, 2024.

Table 21 – Players' average percentage of best response by number of CRT hits

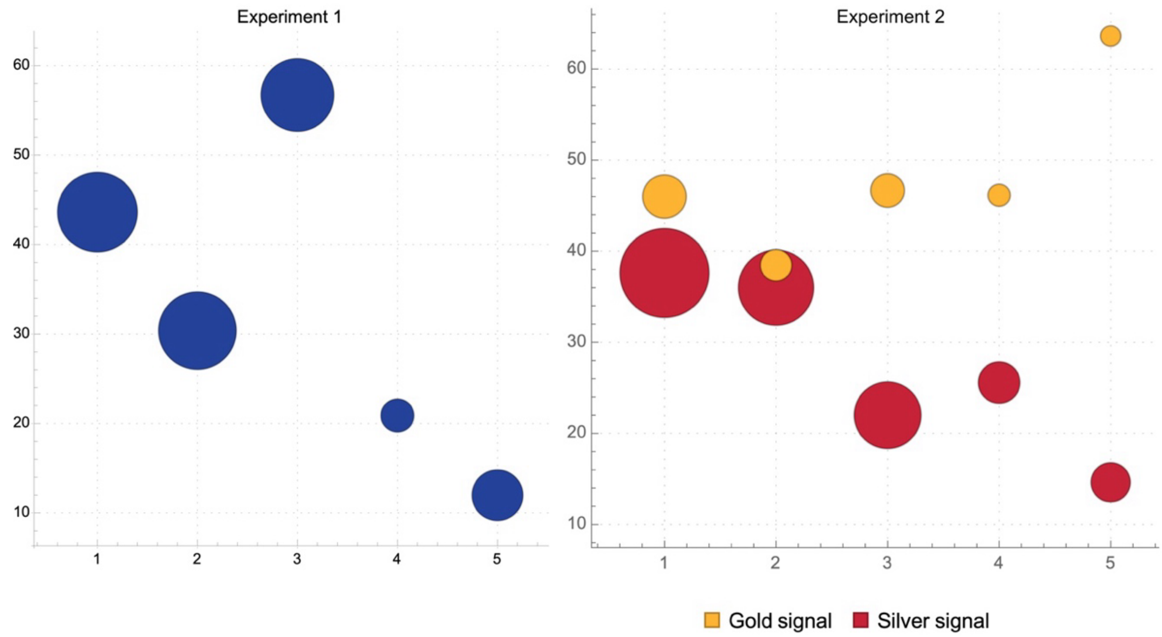
Cognitive reflection test correct answers	Players best response (%)	
	Experiment 1	Experiment 2
0	45.9%	60.0%
1	49.3%	62.7%
2	63.9%	71.1%
3	73.9%	73.2%

Source: research data, 2024.

Looking at the data, either in Table 21 or in Figure 31, it appears that players who achieved a higher score in the cognitive reflection test had a higher average percentage of following the best response given each scenario. In the first experiment, players with no hits in CRT only followed the best response, on average, 45.6% of the time. The same happened 60% of the time in experiment 2. Analyzing the boxplots in Figure 31, it can be seen that the higher limit reaches 100% of the best response for 3 hits in the CRT in both experiments. However, in experiment 1 (blue boxplot), there are some low outliers for the same score, which did not happen in experiment 2. Further cognitive reflection skills analysis will be commented on after logistic regressions.

Although Figure 28 and Table 20 show the probability of following the unanimous majority in UMS, it is fundamental to understand what happened in non-UMS as well. Therefore, the probability of following the minority (%) (*y-axis*), the difference between majority and minority (*x-axis*), and the number of occurrences (circle size) were combined. This analysis can be seen in Figure 32.

Figure 32 – Bubble chart: probability of following the minority (%)

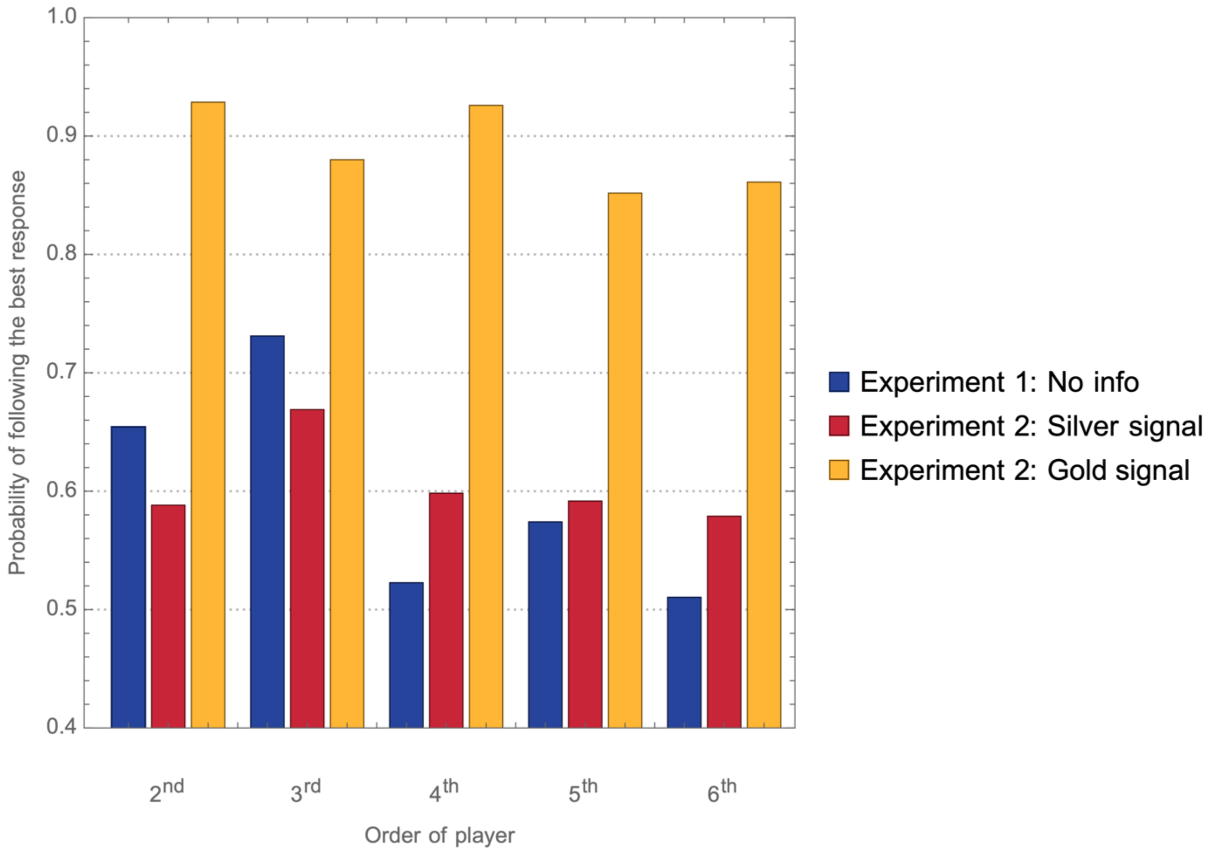


Source: research data, 2024.

Figure 32 shows that in experiment 2, it could be seen a difference in players' behavior patterns by the type of signal received: players that received the silver signal (red bubbles) tend to follow less the minority whenever there is a larger majority, i.e., the chances of following the minority when there a scenario like (5,0) or (4,1) is smaller when there is a scenario like (2,1). The same pattern appears to happen in experiment 1, as shown by the blue bubbles. However, for players that received the gold signal, it appears that this behavior did not adhere to participants, as seen in the yellow bubbles behaved differently.

Furthermore, the probability of a player choosing the best response given each scenario presented to them was estimated and segmented by the order of the participants in that round. The results are shown in Figure 33.

Figure 33 – Probability of following the response (by order of player)



Source: research data, 2024.

It can be seen that, as expected, players with the gold signal in experiment 2 followed their private signal most of the time (probability of 0.85 or higher). Regarding the silver signal, it could not be seen as a behavior pattern in the first analysis. In experiment 1, players followed the best response with a higher probability when they were the second or third players (0.65

and 0.73, respectively). After that, the probability reduced to values below 0.58. Further analysis will be commented on after logistic regressions.

In the whole analysis, it can be seen that the H2 has been rejected as players didn't always follow the best response, that is, they didn't act rationally 100% of the time. This can also be seen in Tables 10 and 19, where it is shown that, in experiments 1 and 2, around 31% and 41% of players, respectively, deviated from the choice that would give them a higher probability of choosing the good restaurant.

5.3 REGRESSION ANALYSIS

Following the results analysis, logistic regressions were estimated according to procedures previously stated in the methodology section. Using *StataMP* software and the equations stated in subsection 4.6, the results will be presented next in this subsection. The first regression performed was a logistic regression where the dependent variable was a binary variable which was given 1 value whenever players followed the best response and given 0 whenever they did not. From the gathered data collected in experiment 1, it was used the non-sequential treatment (first 10 rounds), players did not have the information and there was not a tie. The results are as follows (from now on, also called results A):

Table 22 – Logistic regression A estimations: experiment 1

Predictor	**Coefficient**	**Standard error**	**Odds ratio**	**z**	**p-value**	
Intercept	1.62987	0.3789681	5.10321700	4.30	0.000	***
Time (t)	-0.017619	0.0201155	0.98253462	-0.88	0.381	
CRT hits	0.42990	0.0519255	1.53710012	8.28	0.000	***
Non-unanimous	-1.65545	0.1829716	0.19100589	-9.05	0.000	***
Age	-0.00447	0.006402	0.99554008	-0.70	0.485	
Gender	-0.27034	0.1122041	0.76312213	-2.41	0.016	**
Marital	0.04874	0.0565646	1.04994733	0.86	0.389	
Education	-0.13120	0.0550163	0.87704095	-2.38	0.017	**
Employment	-0.07329	0.0628543	0.92933528	-1.17	0.244	
Income	-0.03535	0.0323452	0.96526385	-1.09	0.274	

Note: ***, **, and * denotes significance at the 1%, 5%, and 10% levels, respectively. Estimations used robust standard errors. Italic named predictors are dummy variables (*Gender*: 0: female; 1: male). $\chi 2$ = 142.25, p-value = 0.000.

The logistic regression was performed to assess the effects of CRT hits, time evolution, the type of majority (unanimous or not), and control variables on the likelihood of choosing the best response. The logistic regression was statistically significant. As shown in Table 22, the statistically significant variables were related to CRT hits, the dummy variable *non-unanimous,* and control variables related to participants' gender and education.

The CRT hits odds ratio shows that for each hit in the CRT, there is a 53.7% increase in the chance of following the best response, i.e., acting more rationally. This result supports hypothesis H7. The coefficient of variable *non-unanimous* has a negative which gives an odds ratio of 0.191, which means that for scenarios that were a non-unanimous scenario, players had 5.23 less chance of choosing the best response. This statement is related to hypothesis H1, which states that players are less likely to realize when their best course of action is to follow the minority. As the results show a statistical relationship, it can be said that players find it harder to act rationally when the rational choice was to follow the minority. I.e., there is a significant relationship. Regarding the gender variable odds ratio (0.763), it is shown that, in the analyzed sample a man had around 30% less chance of choosing the best response when compared to a woman *coeteris paribus*. The educational level also had a negative influence, which means that, in this sample, players with more years of study had less chance of following the best response.

The next logistic regressions were estimated to understand if the size of the unanimous majority matters or the difference between predecessors "inside" each restaurant (the number of majority less the number of minority). Therefore, a new variable called diff majority was added, which contains this information. The regression results (called B and C) are shown next in Table 23.

Table 23 – Logistic regressions B and C estimations: experiment 1

Type of majority	Unanimous majority (B)						Non-unanimous majority (C)					
Predictor	**Coefficient**	**Standard error**	**Odds ratio**	**z**	**p-value**		**Coefficient**	**Standard error**	**Odds ratio**	**z**	**p-value**	
Intercept	0,7043235	0,6013517	2,02247802	1,17	0,242		-1,2119790	0,8811459	0,29760773	-1,38	0,169	
Time (t)	-0,0841632	0,0231922	0,91928122	-3,63	0,000	***	0,0994856	0,0344526	1,10460256	2,89	0,004	***
CRT hits	0,295521	0,0652822	1,34382631	4,53	0,000	***	0,479198	0,1035578	1,61477883	4,63	0,000	***
Duration	0,0001595	0,0001618	1,00015951	0,99	0,324		0,0001463	0,0001979	1,00014631	0,74	0,460	
Diff majority	0,1808452	0,0535061	1,19822968	3,38	0,001	***	-0,1743984	0,1196271	0,83996219	-1,46	0,145	
Age	-0,0143714	0,0098798	0,98573138	-1,45	0,146		0,0108099	0,0169955	1,01086854	0,64	0,525	
Gender	-0,0712978	0,1461623	0,93118454	-0,49	0,626		-0,6852936	0,2321249	0,50394225	-3	0,003	***
Marital	0,1009047	0,0773072	1,10617122	1,31	0,192		-0,0637637	0,1295168	0,93822668	-0,49	0,622	
Education	0,0685223	0,075253	1,07092451	0,91	0,363		-0,1046994	0,1030875	0,9005952	-1,02	0,310	
Employment	-0,0955401	0,0969769	0,90888191	-0,99	0,325		0,0288007	0,1467412	1,02921945	0,2	0,844	
Income	-0,0986486	0,0466522	0,90606104	-2,11	0,034	**	0,0373398	0,0793538	1,03804569	0,47	0,638	

Note: ***, **, and * denotes significance at the 1%, 5%, and 10% levels, respectively. Estimations used robust standard errors. Italic named predictors are dummy variables (*Gender*: 0: female; 1: male). Model B $\chi 2$ = 50.20, p-value = 0.000; Model C $\chi 2$ = 39.12, p-value = 0.000.

Both models B and C were statistically significant, as shown by Wald chi-square p-values (0.000). Table 23 shows the difference between the same variables and their influence regarding the type of majority: unanimous or not.

First, regarding model B, the variables that showed statistical significance were related to time evolution, CRT hits, income, and the variable *diff majority*. In this model, were filtered only scenarios with unanimous majority (such as (1,0), (2,0), (3,0), (4,0) or (5,0)). Concerning the CRT hits variable odds ratio, it is possible to see that players that got 1 more hit in the cognitive reflection test, it would have 34.4% more of choosing the best response *coeteris paribus*.

The time evolution coefficient presented a negative value (-0.0841632), which means that, for each round that went on, players had 8.78% less odds of choosing it rationally (opting for the best response answer). When looking at these scenarios only, players had their best response performance decreased across time. This rejects the null hypothesis of the H5 (which states that subjects learn over time), but it goes in the opposite direction than expected. The blue plot shown in Figure 29 shows that players across rounds became “majority avoiders” as the ratio of players that chose majority decreased over time. Therefore, combining these information it allows to estimate that players stopped choosing the majority regardless of it was the rational choice or not. If they had followed the best response in these scenarios of a unanimous majority, they would have chosen to follow this majority. However, it was not what happened.

The variable related to the size of the unanimous majority (*diff majority*) coefficient presented a positive value, which means a positive influence over the dichotomous dependent variable. The odds ratio means that for each new predecessor that had chosen the unanimous majority (variable value increase equal to one), the next player had a 19.8% higher odds of choosing the best response after him/her (which was follow the unanimous majority as well). This rejects the null hypothesis of H6 and confirms the alternative hypothesis: majority unanimity size influences subjects’ decision-making.

These two last results could relate to the social transmission bias previously commented in subsection 2.2, which refers to the fact that signals and ideas are systematically modified in their transfer from a sender to a receiver. As stated before: social transmission bias results from a combination of sender bias (in the information that is sent) and receiver bias (in the information that is observed and understood). As stated by Bikhchandani et al. (2021) and Hirshleifer (2020a), a primary implication of social learning is that people who observe others’ choices often begin to behave in similar ways.

Lately, it was seen that the income coefficient showed a negative value, which states that participants with higher personal annual income, had lower chances of following the best response.

Regarding model C estimations, Table 23 shows that the following variables were statistically significant at 1% of the significance level: CRT hits, time evolution, and gender. Contrary to model B, in model C, the time variable coefficient presented a positive value, which means that, for these cases, players learned across time and followed the best response with a higher probability. According to the estimated odds ratio related to this variable, for each round that went on, the probabilities of choosing the best response were raised by 10.4%. This result supports hypothesis H5, which states that subjects learn across time.

The CRT hits coefficient in model C was statistically significant and revealed a positive value. The odds ratio showed that for each new hit that players got, they would have 61.4% chances of following the best response *coeteris paribus*. This result supports hypothesis H7. For the gender-related variable, its estimations showed an odds ratio (0.50394225) that whenever a player was a man, he had less chances to following the best response if compared to a female player *coeteris paribus*.

Comparing models A, B and C, it can be seen that the almost the same variables showed statistical significance. In the results of model A, it was possible to identify that the type of majority (unanimous or not) had influence over the dependent variable. Therefore, new estimations were made for each scenario. It was possible to see that, in model B, time evolution showed a negative influence, but in model C, it showed a positive value. Therefore, it was estimated a new model (D) which contained an interaction between the proposed moderator variable (type of majority) and the moderated variable (time).

So, the logit which parameters it was tried to estimate was given by:

$$Z_i = \alpha + \beta_1.CRT_{it} + \beta_2.t + \beta_3.D_{non-unanimous_{it}} + \beta_4.(t \times D_{non-unanimous_{it}}) + \beta_k.\delta_{it} \tag{22}$$

Thus, the logistic regression used to analyze was given by:

$$p_i = \frac{e^{(\alpha+\beta_1.CRT_{it}+\beta_2.t+\beta_3.D_{non-unanimous_{it}}+\beta_4.(t \times D_{non-unanimous_{it}})+\beta_k.\delta_{it})}}{1 + e^{(\alpha+\beta_1.CRT_{it}+\beta_2.t+\beta_3.D_{non-unanimous_{it}}+\beta_4.(t \times D_{non-unanimous_{it}})+\beta_k.\delta_{it})}} \tag{23}$$

Results are shown next in Table 24.

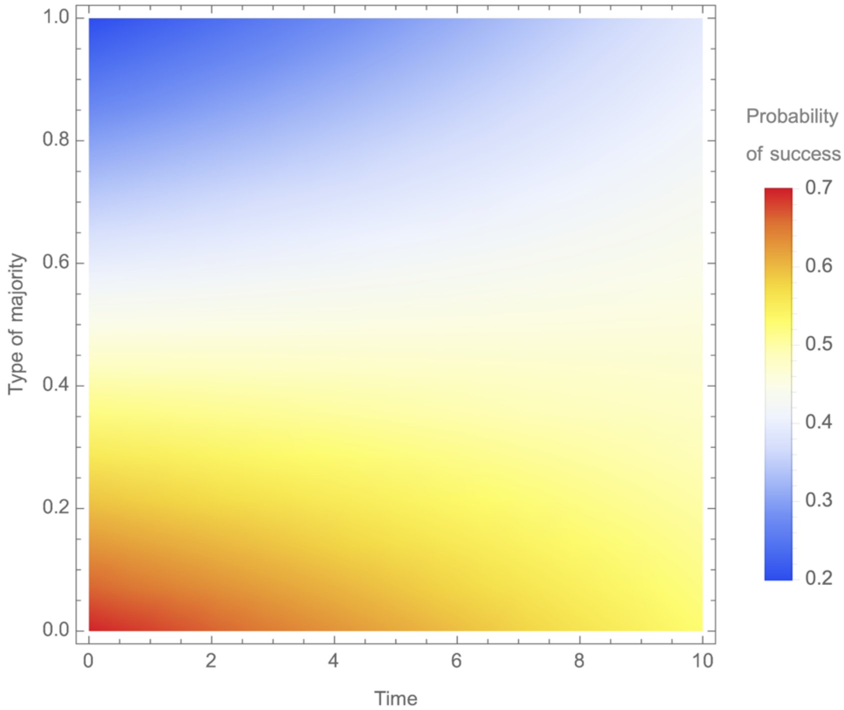
Table 24 – Logistic regression D estimations: experiment 1

Predictor	Coefficient	Standard error	Odds ratio	z	p-value	
Intercept	1.021146	0.3758812	2.77637467	2.72	0.007	***
Time (t)	-0.0755783	0.0223814	0.92720713	-3.38	0.001	***
Non-unanimous	-2.23422	0.2460924	0.1070753	-9.08	0.000	***
Time × *non-unanimous*	0.1607295	0.0357580	1.17436726	4.49	0.000	***
CRT hits	0.3231883	0.0482915	1.38152547	6.69	0.000	***
Duration	0.0001445	0.0001129	1.00014451	1.28	0.201	
Age	-0.0068519	0.0057741	0.99317152	-1.19	0.235	
Gender	-0.2541706	0.1047469	0.77555948	-2.43	0.015	**
Marital	0.0511617	0.0531638	1.05249307	0.96	0.336	
Education	0.0142062	0.0532901	1.01430759	0.27	0.790	
Employment	-0.0464066	0.0587691	0.95465372	-0.79	0.430	
Income	-0.045496	0.0294962	0.955234	-1.54	0,123	

Note: ***, **, and * denotes significance at the 1%, 5%, and 10% levels, respectively. Estimations used robust standard errors. Italic named predictors are dummy variables (*Gender*: 0: female; 1: male). $\chi 2$ = 165.30, p-value = 0.000.

Estimated logistic regression results show that the proposed model is statistically significant, according to the Wald chi-square test (165.30, *p-value* 0.000). More specifically, the variables that showed statistical significance were: time, the non-unanimous dummy, the interaction between them, CRT hits and the gender dummy. In this model, it was analyzed as the kind of majority, i.e., if it was unanimous or not, to be the moderator variable and the time variable influence over the model's dependent variable moderated by the first one. As the interaction between them was statistically significant, it can be said that there is a moderation relationship. It is shown that the time variable coefficient had a negative value, however it is important to see that that the dummy variable *non-unanimous* also had a negative value and the coefficient of their interaction is positive. So, for a better analysis of these interactions, a line plot was elaborated. The result can be seen next in Figure 34.

Figure 34 – Density plot – model D: experiment 1



Source: research data, 2024.

Moderation analysis through figure 34 allows to better see the interaction between the moderator variable (time of majority) and the moderated variable (time). This interaction shows that there is a difference in players' behavior across time *coeteris paribus*.

Examining Figure 34, it is possible to observe the behavior probability of success in the analyzed sample. On the left side, it is possible to see the type of majority in a binary way, the same way as explained in subsection 4.6: it was given 0 whenever the majority was unanimous and given 1 whenever the majority was non-unanimous. That being said, it is possible to see that, for a combination of low values of the *x-axis* (time/rounds) and unanimous majorities, the probabilities of success are higher (red color in the scale). For that same kind of majority, as time goes by, the probability of success decreases *coeteris paribus*. For the attributed value on the left axis as 1, it is possible to see that the probability of success over time increases as the color goes from blue and reaches out to white, almost halfway of the scale. On the contrary, For the unanimous majorities, the probability of success decreases as the rounds go on. This result partially supports H4, which states that there is a moderation relationship between the unanimity of the majority and the best response (the kind of signal part from this hypothesis was further tested in experiment 2).

Following the regression analysis of experiment 2, similar models were estimated, as stated in the methodology chapter and equations of subsection 4.6 as well. The first regression performed for this experiment was a logistic regression where the dependent variable was a binary variable which was given 1 value whenever players followed the best response and given 0 whenever they did not. The best response for each scenario was choosing the alternative that would give players a higher probability of choosing the good restaurant, as described in sub-section 4.4. From the gathered data collected in experiment 2, it was used the non-sequential treatment (first 10 rounds). Differently from experiment 1, now it could include tie scenarios, and players were always informed somehow. The difference lay in the quality of information received: silver signal told the truth 60% of the time, and gold signal told the truth 90% of the time. Players knew about these probabilities and that only one player had the gold signal per round. The results are as follows (from now on, also called results E) in Table 25.

Table 25 – Logistic regression E estimations: experiment 2

Predictor	**Coefficient**	**Standard error**	**Odds ratio**	**z**	**p-value**	
Intercept	0.4565232	0.6469921	1.57857604	0.71	0.480	
Time (t)	0.0331413	0.0246387	1.03369659	1.35	0.179	
CRT hits	0.1926775	0.0744808	1.2124917	2.59	0.010	***
Non-unanimous	-1.18787	0.1883555	0.30486903	-6.31	0.000	***
Duration	0.00010	0.000	1.00010201	0.56	0.579	
Age	-0.0130659	0.0091872	0.98701909	-1.42	0.155	
Gender	0.2316958	0.1732962	1.26073615	1.34	0.181	
Marital	0.0586958	0.0613319	1.0604526	0.96	0.339	
Education	0.0267599	0.0715846	1.02712116	0.37	0.709	
Employment	0.0041529	0.1094092	1.00416154	0.04	0.970	
Income	0.021974	0.0512792	1.02221721	0.43	0.668	

Note: ***, **, and * denotes significance at the 1%, 5%, and 10% levels, respectively. Estimations used robust standard errors. Italic named predictors are dummy variables (*Gender*: 0: female; 1: male). $\chi 2$ = 63.59, p-value = 0.000.

According to the results of the logistic regressions, the estimated mode is statistically significant supported by the Wald chi-square test (63.59, p-value: 0.000). The coefficients that showed statistical significance in this model were only the ones related to CRT hits and the dummy variable regarding the type of majority: unanimous or non-unanimous. For the first one, its odds ratio value shows that players that got one more hit in the cognitive reflection test had approximately 21.2% more chances of following the best response *coeteris paribus*. In the same way as experiment 1, here in experiment 2, the non-unanimous dummy variable coefficient showed a negative value. Its odds ratio value indicates that it was harder for participants to follow the best response when there was a non-unanimous majority (it was 2.28 times harder according to model's estimations).

In the sequence, the analysis segmented the scenarios by adding another dummy variable for players who had received the gold signal (the variable was given as 1 when players had the gold signal and was given as 0 when they had the silver signal). This estimation is called model F. Its results are shown next in Table 26.

Table 26 – Logistic regression F estimations: experiment 2

Predictor	**Coefficient**	**Standard error**	**Odds ratio**	**z**	**p-value**	
Intercept	0.1484507	0.7477961	1.16003561	0.20	0.843	
Time (t)	0.0331328	0.0264693	1.0336878	1.25	0.211	
CRT hits	0.1964272	0.0824567	1.21704672	2.38	0.010	***
Non-unanimous	-1.3330220	0.2008228	0.26367922	-6.64	0.000	***
Duration	0.0001407	0.0001849	1.00014071	0.76	0.447	
Gold signal	1.8784740	0.2968503	6.54351184	6.33	0.000	***
Age	-0.0151719	0.010226	0.98494261	-1.48	0.138	
Gender	0.2524953	0.191758	1.28723345	1.32	0.188	
Marital	0.0438284	0.0765668	1.04480305	0.57	0.567	
Education	0.0433989	0.0801447	1.0443544	0.54	0.588	
Employment	0.0354816	0.1252809	1.03611858	0.28	0.777	
Income	0.0277525	0.0531169	1.02814119	0.52	0.601	

Note: ***, **, and * denotes significance at the 1%, 5%, and 10% levels, respectively. Estimations used robust standard errors. Italic named predictors are dummy variables (*Gender*: 0: female; 1: male). $\chi2$ = 86.59, p-value = 0.000.

The proposed model was statistically significant as Wald chi-square test confirmed (86.59, p-value: 0.000), and its significant variables were: CRT hits, the non-unanimous dummy, and the gold signal dummy. From these estimated coefficients, players with a higher CRT hits score had more odds of following the best response. This variable's odds ratio showed that each new hit increased each player's chance to follow the best response in around 21.7%. Similarly to previously proposed models (including model E), the non-unanimous variable coefficient was negative. According to model's estimations, whenever players faced a non-UMS, they had 2.79 less chances of following the best response. This result supports hypothesis H1.

The gold signal variable coefficient presented a positive value. Its odds ratio showed that players that received the gold signal had higher chances of choosing the best response. This follows as expected: whenever players received the gold signal, they had an information that told the truth 90% of the time. As stated in subsection 4.4, when comparing the probabilities of each restaurant being the good one, the 90% probability of being right was greater than probabilities without information. In that case, it was easy for participants just to follow the given information. The odds ratio of this variable displays that players had around 5.54 more chances of acting rationally when they received a gold signal in comparison with periods when they received a silver signal.

Similar to experiment 1, the analysis followed by splitting the regressions and filtering some specific observations with the goal of better understand players' behavior, strategy or choices across time and each presented scenario. Therefore, the next estimated models are: model G which contains only observations that players had the silver signal, model H which only contains players that had the gold signal, model I which hasn't ties and has only non-unanimous majorities, and model J which hasn't ties but has only unanimous majorities scenarios. Results are shown next in Tables 27 (models G and H) and 28 (models I and J), and their analysis is right after.

Looking at estimations model G, it can be seen that the model was statistically significant according to the Wald chi-square test (62.61, p-value: 0.000), and the following variables were significant as well: time evolution, CRT hits, dummy non-unanimous, and age. The time evolution coefficient showed a positive value, and its odds ratio showed that, for each successive round, participants had 5.82% more chances of following the best response whenever they had the silver signal. The CRT hits odds ratio showed that for each one with a higher score on the test, participants had around 22.3% more chances of choosing rationally. The non-unanimous dummy and age coefficients exhibited negative values in this estimation. The first one explained one more time that players found it 3.15 times harder to follow the best response when there was not a unanimous majority. Surprisingly, the control variable related to participants' age exhibited a negative value, and its odds ratio value estimated that for each year-old, participants had 1.90% less chance of following the best response. These results support hypotheses H1, H5, H7 and H11.

The subsequent analysis was over model H, which showed a statistically significant result as its Wald chi-square test resulted in 18.21 (p-value: 0.05). However, in this model, only the time evolution (rounds) variable was significant and showed a negative value, which states that players did not learn across time, as for each round that went on to next one.

Table 27 – Logistic regressions G and H estimations: experiment 2

Type of signal	**Silver signal (G)**						**Gold signal (H)**					
Predictor	**Coefficient**	**Standard error**	**Odds ratio**	**z**	**p-value**		**Coefficient**	**Standard error**	**Odds ratio**	**z**	**p-value**	
Intercept	0,196421	0,839065	1,21703868	0,23	0,815		1,18801	2,28455	3,28053986	0,52	0,603	
Time (t)	0,0565409	0,0289361	1,05816989	1,95	0,050	**	-0,1978481	0,0998623	0,82049448	-1,98	0,048	**
CRT hits	0,2013111	0,0901524	1,22300519	2,23	0,026	**	0,1975351	0,2196005	1,21839583	0,90	0,368	
Non-unanimous	-1,424584	0,2267797	0,24060854	-6,28	0,000	***	-0,792833	0,5654243	0,45256087	-1,40	0,161	
Duration	0,0001917	0,0002069	1,00019172	0,93	0,354		-0,0001543	0,0004662	0,99984571	-0,33	0,741	
Age	-0,0188107	0,0108732	0,98136512	-1,73	0,084	*	0,015348	0,0426539	1,01546639	0,36	0,719	
Gender	0,2753411	0,2092951	1,31697982	1,32	0,188		-0,0262754	0,5062554	0,97406679	-0,05	0,959	
Marital	0,0532582	0,0825791	1,05470193	0,64	0,519		0,0188443	0,29223	1,01902297	0,06	0,949	
Education	0,0184225	0,0894042	1,01859324	0,21	0,837		0,2584048	0,2762167	1,29486287	0,94	0,350	
Employment	0,0146796	0,1366756	1,01478787	0,11	0,914		0,5184247	0,4408226	1,67938004	1,18	0,240	
Income	0,0456294	0,0557912	1,04668644	0,82	0,413		-0,11236	0,14516	0,89372532	-0,77	0,439	

Note: ***, **, and * denotes significance at the 1%, 5%, and 10% levels, respectively. Estimations used robust standard errors. Italic named predictors are dummy variables (*Gender*: 0: female; 1: male). Model G $\chi2$ = 62.61, p-value = 0.000; Model C $\chi2$ = 18.21, p-value = 0.05.

Table 28 – Logistic regressions I and J estimations: experiment 2

Type of signal	**Unanimous majority (I)**						**Non-unanimous majority (J)**					
Predictor	**Coefficient**	**Standard error**	**Odds ratio**	**z**	**p-value**		**Coefficient**	**Standard error**	**Odds ratio**	**z**	**p-value**	
Intercept	0,0940387	1,1779640	0,24618155	-1,29	0,198		0,0940387	1,1779640	0,52771918	0,08	0,936	
Time (t)	-0,0323854	0,0412524	0,96813339	-0,79	0,432		0,0803411	0,0518005	1,02055296	1,55	0,121	
CRT hits	0,3312272	0,1275035	1,39267617	2,6	0,009	***	-0,0390219	0,1317613	1,18505537	-0,30	0,767	
Duration	0.0006571	0,0002666	1.00065732	2,46	0,014	**	-0,0001165	0,0002693	1,00036657	-0,43	0,665	
Diff majority	0,2998983	0,0972966	1,34972153	3,08	0,002	***	-0,5241528	0,1851162	1,23333959	-2,83	0,005	***
Age	0,0029151	0,0164524	1,00291935	0,18	0,859		-0,0036747	0,0177232	0,99121343	-0,21	0,836	
Gender	0,3269753	0,2947105	1,38676722	1,11	0,267		0,2076024	0,2988231	1,40397416	0,69	0,487	
Marital	-0,0215216	0,1080231	0,97870834	-0,2	0,842		0,1585773	0,1521924	1,03429858	1,04	0,297	
Education	0,0308029	0,1412176	1,03128222	0,22	0,827		-0,0436681	0,1423294	0,95889912	-0,31	0,759	
Employment	0,0251839	0,1936351	1,02550369	0,13	0,897		0,0692488	0,2442168	1,03517438	0,28	0,777	
Income	0,0712188	0,0919298	1,07381615	0,77	0,439		0,0781007	0,1115405	1,05970058	0,70	0,484	

Note: ***, **, and * denotes significance at the 1%, 5%, and 10% levels, respectively. Estimations used robust standard errors. Italic named predictors are dummy variables (*Gender*: 0: female; 1: male). Model I $\chi2$ = 22.2, p-value = 0.014; Model J $\chi2$ = 12.51, p-value = 0.253.

In Table 28, looking at model I estimations (unanimous majorities), it can be seen that the model showed statistical significance according to the Wald chi-square test (22.2, p-value: 0.014). The significant variables were related to CRT hits, duration, and *diff majority*.

For the CRT hits coefficient, it was estimated a positive value and its odds ratio showed that for each new hit, players had around 39.3% more chances of following the best response *coeteris paribus*. This result supports hypothesis H7 like previous estimated models. Unlike other models, in model I the coefficient related to the variable *duration* showed statistical significance and negative value. According to its odds ratio shown in table 28, players that took a little bit more time analyzing each decision, had a higher probability of following the best response. In a way, this result follows the positive value related to CRT hits, that analyzes cognitive reflection skills. So, it could be said that players who had higher cognitive skills, were the ones that spent a bit more time analyzing each round before making a decision. That is, they probably used more their "System 2", as proposed by Frederick (2005a) and Kahneman (2012). This result supports hypothesis H8.

The third significant variable was related to the size of the unanimous majority. Its coefficient showed a positive value and its odds ratio showed that, for each new predecessor that followed the unanimous majority before current player, he/she had 2.34 more time of following the best response which was also to follow him/her. This means that players found it easier to follow bigger unanimous majorities. For example: a participant had a higher chance of acting rationally (follow the majority) when there was a (5,0) scenario than when it was a (1,0) scenario. This finding supports hypothesis H6, which states that majority unanimity size influences subjects' decision-making. Regarding model J estimations, only the variable diff majority showed a statistically significant value, however the model Wald chi-square test (12.51, p-value: 0.253) could not reject the null hypothesis from this model.

At last, it was combined a moderation analysis as shown in subsection 4.6. In the next estimated model, it was tested a three-way interaction: "often thought of as a relationship between a variable *X* and dependent variable *Y*, moderated by variables *Z* and *W*" (Dawson, 2014a, p. 1), where the *X* variable was time evolution (rounds), *Y* variable was binary about players following the best response (or not), moderator *Z* variable was the type of signal received (silver or gold) and moderator *W* variable was the type of majority (unanimous or not). Estimated results of model K are shown in table 29.

Table 29 – Logistic regression K estimations: experiment 2

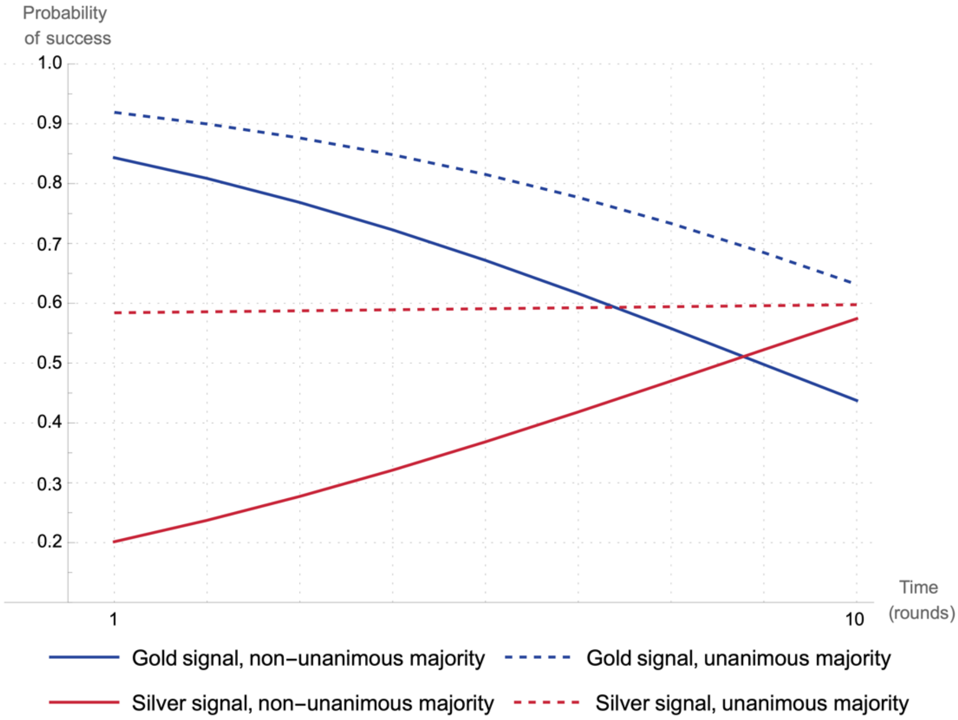
Predictor	Coefficient	Standard error	Odds ratio	z	p-value	
Intercept	0,3158426	0,7184348	1,37141438	0,44	0,660	
Time (t)	0,0060807	0,0296119	1,00609922	0,21	0,837	
CRT hits	0,2005508	0,0783831	1,22207569	2,56	0,011	**
Non-unanimous	-2,40008	0,4251419	0,0907107	-5,65	0,000	***
Gold signal	2,91240	0,8075434	18,4008342	3,61	0,000	***
Time × *Gold signal*	-0,2111899	0,1115494	0,80962031	-1,89	0,058	**
Time × *non-unanimous*	0,1757064	0,0652099	1,19208801	2,69	0,007	***
Gold signal × *non-unanimous*	1,67076	1.537.921	5,31618	1,82	0,069	**
Time × *non-unanimous* × *gold signal*	-0,18036	0,2083425	0,8349689	-1,90	0,057	**
Age	0,00011	0,0001858	1,00011141	0,60	0,549	
Gender	-0,0145725	0,0101394	0,98553316	-1,44	0,151	
Marital	0,0727293	0,0727287	1,07543938	1,00	0,317	
Education	0,054351	0,0789049	1,05585514	0,69	0,491	
Employment	0,0635886	0,1240136	1,0656539	0,51	0,608	
Income	0,0451586	0,0533361	1,04619377	0,85	0,397	

Note: ***, **, and * denotes significance at the 1%, 5%, and 10% levels, respectively. Estimations used robust standard errors. Italic named predictors are dummy variables (*Gender*: 0: female; 1: male). $\chi 2$ = 94.75, p-value = 0.000.

Following the Wald chi-square, it is possible to say that the model is statistically significant (94.75, p-value: 0.000). More specifically, the following variables were significant: CRT hits, the dummy related to unanimity of majority, the dummy related to kind of received signal in that round (silver or gold) and the proposed interaction between the moderated and moderator variables. According to Dawson (2014a, p. 1), the three-way interaction term must be statistically significant in the regression estimation results so the interaction can be interpretable. This result supports hypothesis H4.

To better visualize these interactions and the moderation analysis, a plot combining variables *X*, *Y*, *W*, and *Z* was elaborated, as proposed by Dawson (2014a, 2014b), and can be seen in Figure 35.

Figure 35 – Moderation analysis – model K: experiment 2



Source: research data, 2024.

In the figure above, following its below label, it can be seen that the gold signal is represented by the blue line, and the silver signal is the red line, and also the type of majority is represented by the type of the line: straight line for non-unanimous majorities and dashed line for unanimous majorities. Therefore, comparing the blue lines, it is possible to see that players across time noticed that sometimes the gold signal could give a wrong information 10% of the time and, in some cases, players disregarded their private information and followed the public information that was shown to them: the total of predecessor players that had chosen each restaurant. This somehow corroborates the social transmission bias where players had an attraction for a particular option but there was not necessarily a preference for it (Bikhchandani et al., 1992, 2021; Hirshleifer & Teoh, 2009)

Looking at the players who had received a silver signal, it can be seen in the red and dashed line that for unanimous majorities, players did not learn that much across time. However, for non-unanimous majorities, players that were considered “less informed” learned over time as the red and regular line increases inside the plot. This result supports hypotheses H5 and also H1, which state that subjects are less likely to realize when their best course of action is to follow the minority, as proposed by the model of Callander and Hörner (2009a).

So, comparing only the continuous lines, that means, the non-unanimous majorities, it can be said that the kind of signal received moderates the influence of subjects' learning behavior: for rounds where players received the silver signal, players started to analyze more the probabilities and each scenario in a way that it improved their average chances of following the best response. Nevertheless, when they received a gold signal, they should have followed their private signal as it was the response that would give them a higher probability of choosing the right restaurant, but over time, players started to incur in the social transmission bias.

Observing, more specifically, the continuous blue line, which illustrates players' behavior when they had received the gold signal, and there was a unanimous majority. It is important to realize that these scenarios were given as (1,0), (2,0), (3,0), etc., and, if players were uninformed, the best response to them would be to follow their unanimous predecessors. However, in this blue line players did receive an information and they should had followed to it, regardless of their score.

As previously stated, for Hirshleifer (2020b), social transmission bias discusses the fact that signals and ideas are systematically modified in their transfer from a sender to a receiver. A crucial implication of social learning is that people who observe others' choices often begin to behave in similar ways (Bikhchandani et al., 2021), which could explain players' behavior when they disregarded their private (gold) signal. Thus, it is understood that in some cases, economic agents observe the social context in which they are included and may behave differently from the market or their individual preferences (Bikhchandani et al., 2021; Hirshleifer & Teoh, 2009).

Social transmission bias refers to a signal distortion (shifts in sign or intensity of what is transmitted) and in whether something is transmitted or not, from the sender to the receiver. As previously stated, social emergence arises when subjects can be attracted to a behavior, an option, an alternative, without any preference for it (Hirshleifer, 2020c). That being said, it was possible to see that, in both experiments, players whey they did not choose the best response alternative, over the time, they became "majority avoiders", i.e., they started to follow the minority more frequently. That happened when players deviated from the rational alternative. So, it could be seen that players were attracted to a specific alternative, but they did not have any preference for it. This circumstance proves social transmission bias as players were not following the majority, like a conventional herd behavior. Also, it was possible to see that what previous players had chosen had influence over the subsequent players: sometimes the immediate previous player, in other cases the deviator who changed the unanimous majority scenario to a non-unanimous scenario. Therefore, it could be seen that, in some cases, only one previous player could break the informational cascade and distort the public information that would be shown to the next subject before he/she makes a decision.

5.4 HYPOTHESES EXAMINATION

As previously mentioned in subsection 4.6, some hypotheses were developed to explain this study and answer the objective goals, which could answer the main research goal. So, this subsection summarizes the hypotheses and their final analysis: whether it was possible to prove, reject or not their statements.

The first one was hypothesis H1, which stated that subjects are less likely to choose when their best course of action is to follow the minority. According to the non-unanimous dummy variable that was statistically significant in models A, D, E, F, G, I, and K, its estimated coefficient showed a negative value, indicating that players' odds ratio of following the best response in these scenarios was lower.

Hypothesis H2 stated that subjects always act rationally, and it was rejected as it was seen that players did not always act rationally, and sometimes their behavior diverged from the best response. That being said, H3 investigated which behavior pattern arose from subjects that deviated from the best response. Looking at the gathered data, it appears that when players deviated from their best response, on average, they became "majority avoiders" (or could also be called "minority lovers"). So, in a whole analysis, it was possible that players across time, whenever they deviated from the best response, they tended to follow the minority. This also corroborates hypothesis H3.B and simultaneously rejects hypothesis H3.A and H3.C.

Regarding hypothesis H4, which stated that there could be a moderation relationship between the unanimity of the majority, the kind of signal, and the best response, it was possible to confirm this hypothesis when models D and K showed statistical significance for their moderation analysis. In model D, it was possible to see that the kind of majority (unanimous or not) moderated the influence of the variable time across players' decisions. Also, in model K, it was possible to corroborate the moderation between players' learning across time by the kind of signal received (silver or gold) and the kind of majority as well (unanimous or not). Looking at hypothesis H5, which stated that subjects learn over time, it was possible to see that in some models (C and G) players actually learned across time, but in some cases their behavior followed an opposite path: they were less likely to choose the best response as the round went on (models B and H). Nevertheless, the main results were explained by the moderation analysis in models D and K: agents' learning process were moderated by 2 other variables: the unanimity of majority and the quality of signal received (silver or gold).

The next corroborated hypothesis was H6, which stated that majority unanimity size influences subjects' decision-making. In the first experiment, according to model C estimations, it was possible to visualize that the bigger the difference between the unanimous majority alternative, the higher odds players had to choose the best response (ex.: (4,0) vs. (1,0)). In experiment 1, the majority size had influence when there was a UMS, but when there was a non-UMS, the coefficient related to this variable did not show statistical significance (model D). However, in experiment 2, similar results happened. For UMS, the coefficient related to the majority's size had a positive and statistically significant value. Nevertheless, differently from experiment 1, in experiment 2, non-UMS players had an opposite influence on the majority size. Therefore, it can be said that majority size does matter over decision-making.

After the experiment, players answered a cognitive reflection test and in models A, B, C, D, E, F, G, I and K, the cognitive reflection skills were positively related to the probability of players following the best response. This means that, on average, players who scored more in the CRT had the best chances of thinking more strategically and, therefore, choosing the answer that would give them a higher probability of choosing the good restaurant. This corroborates hypothesis H7, which states that cognitive reflection skills are related to rationality in decision-making. Regarding hypothesis H8, which stated that time spent on decision-making influence its outcome, it could be only corroborated in model I, which showed that players who took more time analyzing in each round had higher odds of following the best response. According to its odds ratio shown in table 28, for each second spent in these cases, players had 0.06% higher chances of choosing the best response option.

Based on hypothesis H9, which stated that subjects' behavior differs between genders, there was a difference between genders in this dummy variable in models A and C (experiment 1). Both models' coefficients related to this dummy variable showed a negative value. As the dummy variable was coded as 1 for male participants, the models' results estimate that female participants had higher odds of following the best response *coeteris paribus*. These results go in the opposite direction as the results found by (Avram, 2018), who found in her sample that male participants had higher cognitive abilities.

Regarding subjects' educational level influences decision-making (H10), although the data by (Avram, 2018) showed that educational level had a positive influence over CRT results, in the gathered data in this study, it was not possible to find a significant statistical difference in almost every model, except model A, which showed a variable related coefficient with a negative value. Therefore, in a broader analysis, looking at all models, there was not a statistical difference. Finally, looking at participants' age influence over decision-making (H11), the coefficients related to this variable were not significant in all models but model G. In model G, the coefficient showed a negative value, which means that older players had lower chances of following the response alternative, which goes in the opposite direction as the results shown by (Avram, 2018). A complete summary of the previously established hypothesis is shown next in Table 30.

Table 30 – Hypotheses examination summary

Hypothesis	Statement	Empirical findings	Result
H1	Subjects are less likely to choose when their best course of action is to follow the minority	Dummy variable $D_{non\text{-}unanimous}$ showed a negative and statistically significant in models A, D, E, F, G, I, K	Supported
H2	Subjects always act rationally	Subjects didn't follow the best response in 100% of the times	Rejected
H3	Which behavior pattern arises from subjects that deviate from the best response?	Players across time became "majority avoiders" (ratio of players that followed the majority *vs*. minority)	Explained
H3.A	When subjects deviate from the best response they follow the majority		Rejected
H3.B	When subjects deviate from the best response they follow the minority		Supported
H3.C	When subjects deviate from the best response they choose randomly		Rejected
H4	There is a moderation relationship between the unanimity of the majority, the kind of signal, and the best response	Statistical significance of moderation analysis in models D, K	Supported
H5	Subjects learn over time	Subjects' behavior changed across time, but they only learned in some cases (the learning process was moderated by the unanimity of majority and kind of signal received)	Partially supported
H6	Majority unanimity size influences subjects' decision-making	Variable *diff majority* coefficient showed positive and statistically significant value in model C	Supported
H7	Cognitive reflection skills are related to rationality in decision-making	CRT score coefficient was statistically significant in models A, B, C, D, E, F, G, I, K	Supported
H8	Time spent on decision-making influence its outcome	Variable related to time spent by players making a decision was only statistically significant in model I	Rejected
H9	Subjects' behavior differs between genders	Dummy variable gender coefficient was statistically significant in models A, C	Partially supported
H10	Subjects' educational level influences decision-making	Educational level coefficient was only statistically significant in model A	Rejected
H11	Subjects' age influences decision-making	Coefficient of variable age was only statistically significant in model G	Rejected

Source: research data, 2024.

6 CONCLUDING REMARKS

This section recapitulates the study, summarizing its methods, data, results and implications. This study analyzes the emergence of social transmission bias through the wisdom of the minority.

The purpose of this study was to understand the extent to which the decision-making process of following the minority can be systematically influenced. In this quantitative and cross-sectional study, two experiments were conducted which had 321 validated answers. Both experiments were conducted as a rationality experiment to see if economic agents were able to understand that following the minority in some circumstances was the best strategy. The experiments were conducted on computers based on the *z-Tree* software (*Zurich Toolbox for Readymade Economic Experim*ents) developed by the University of Zurich. The sessions consisted of 6 participants, according to feasible mathematical probability, following the model by Callander and Hörner (2009). In each round, there was 1 participant who was better informed than the other ones. He/she had a private information, which revealed (only to him/her) which was the correct alternative in that round while the other participants knew of the existence of an informed participant, but he/she stayed anonymous.

Eleven logistic regression models were estimated to understand and analyze which variables could influence subjects' behavior across the experiment: for the first experiment, four logistic regression were estimated (from models A to D), and for the second experiment, seven models were estimated (from models E to K). In some of them, moderation variables were added to explain better the interaction between the dependent variable and their independent variable.

Cognitive reflection ability was measured by CRT hits and emerged as a significant predictor, with higher scores correlating with a greater likelihood of rational choices. This result agrees with Frederick (2005b) and Otero et al. (2022), who stated that players with higher CRT hits had better numerical ability, verbal ability, perceptual speed, numeracy skills, memory-capacity, etc.

Also, the type of majority, whether unanimous or not, significantly impacted decision-making. Non-unanimous scenarios reduced the probability of rational decisions. According to Hirshleifer and Teoh (2009), the information cascade has a fragility that a small disclosure of public information can change a well-established and conventional pattern of behavior and break the information cascade. This is related to the unanimity of the majority presented to subjects in the experiment: if there was a deviator from the unanimous majority, players sometimes changed their course of action and, therefore, their likelihood of choosing the best response alternative (the one that would give them higher probabilities of choosing the good restaurant). This aligns with the theory of social transmission bias as stated by (Bikhchandani et al., 1992, 2021; Hirshleifer & Teoh, 2009) where players had an attraction for a particular option but there is not necessarily a preference for it.

Subsequent regressions investigated the influence of the size of unanimous majorities. The findings showed a positive relationship between the size of the unanimous majority and the likelihood of rational choices. As stated by Bikhchandani et al. (2021), when in a cascade position, the individual's information is not relevant for the next agent to make a decision, it is assumed that social learning is blocked. Public information disclosure can be a factor that stops (or even reverses) the information cascade (Bikhchandani et al., 1992), as it can both provide direct information to the individual and can also change the opinion of previous agents, thereby altering the information conveyed by their decisions.

Subjects demonstrated a propensity to learn over time in scenarios with unanimous majorities, but this learning effect was absent in non-unanimous scenarios. Additionally, players tended to follow the majority even when such choices conflicted with their private information, indicating a noticeable social transmission bias. Even though public information is sometimes "noisy," i.e., loaded with a certain amount of noise, it reduces the information transmitted to the second agent by the first agent's decision so much that it ends up overcoming the direct positive effect. According to Bikhchandani et al. (1992), cascades' fragility appears systematically because they provide precarious equilibriums.

The analyzed sample also showed, in some estimated models, that: higher personal income was associated with a reduced likelihood of rational choices, suggesting potential economic influences on decision-making. Gender and education level also showed weak influence, with men and individuals with higher education demonstrating lower chances of choosing the best response.

Regarding, the patterns in bounded rationality decision-making, the gathered data showed that players did not choose the best response, i.e., acted rationally all the time. Players across rounds became "majority avoiders", as the ratio of players that choose majority reduced over time. Therefore, combining this information allows us to estimate that players stopped choosing the majority regardless of whether it was the rational choice or not.

Therefore, in essence, the study enlightened the intricate interplay between individual traits, social dynamics, and decision-making processes within controlled experimental environments, shedding light on the multifaceted nature of human decision-making. Overall, it was possible to identify the emergence of social transmission bias as subjects followed the minority as they had an attraction for a particular option, but there was not necessarily a preference for it. It was seen that players developed systematical behavior, distinct from ordinary herd behavior. The behavior follows two themes that were stated by Hirshleifer (2020a, p. 1782): “socially emergent behavior often looks completely different from individual propensities” and mimicry, because: “social emergence can […] create the illusion of a direct individual propensity ‘for’ a behavior when no such propensity exists”.

Also, it could be said that players with higher cognitive ability would have lower chances of following the information cascade because they would have higher numeracy skills and, therefore, would choose the best response alternative (the one that gave higher chances of choosing the good restaurant) more frequently. It was seen that players did not always act rationally, and subjects were less likely to realize when their best course of action is to follow the minority. The attempt to follow a behavior pattern might be explained by cognitive dissonance theory, in which subjects try to reduce their psychological discomfort, where an individual may reconsider his beliefs about a given decision and what they understand as properly acceptable.

Future research and studies can be conducted using a different sample using a cross-cultural analysis, investigating how cultural differences influence decision-making processes, particularly regarding the impact of social norms and cognitive abilities across different cultural contexts. Also, it could be used in other experimental strategies with larger groups and more options for players (e.g., 50 participants and 5 possible restaurants, only 1 being the good one as well). Other factors that could be added to the analysis are the role of emotions in decision-making, whether players were happy, stressed, sad, etc., and also the chances of them incurring in confirmation bias.

REFERENCES

Aiken, L. S., & West, S. G. (1991). *Multiple Regression: Testing and Interpreting Interactions* (Edição: 1). SAGE Publications, Inc.

Akçay, E., & Hirshleifer, D. (2021). Social finance as cultural evolution, transmission bias, and market dynamics. *Proceedings of the National Academy of Sciences*, *118*(26), e2015568118. https://doi.org/10.1073/pnas.2015568118

Akerlof, G. A., & Dickens, W. T. (1982). The Economic Consequences of Cognitive Dissonance. *The American Economic Review*, *72*(3), 307–319.

Alevy, J. E., Haigh, M. S., & List, J. A. (2007). Information Cascades: Evidence from a Field Experiment with Financial Market Professionals. *The Journal of Finance*, *62*(1), 151–180.

Anache, M. de C. A. (2008). *Finanças comportamentais: Uma avaliação crítica da Moderna Teoria de Finanças* [Dissertação Mestrado em Economia, Universidade Federal do Espírito Santo]. http://repositorio.ufes.br/bitstream/10/5987/1/Dissertacao%20marcelo.pdf (2)

Anache, M. de C. A., & Laurencel, L. D. C. (2013). Finanças comportamentais: Uma avaliação crítica da moderna teoria das finanças. *Revista CADE*, *12*(1), 38.

Anderson, L. R., & Holt, C. A. (1997). Information Cascades in the Laboratory. *The American Economic Review*, *87*(5), 847–862.

Andersson, O., Holm, H. J., Tyran, J.-R., & Wengström, E. (2016). Risk Aversion Relates to Cognitive Ability: Preferences Or Noise? *Journal of the European Economic Association*, *14*(5), 1129–1154. https://doi.org/10.1111/jeea.12179

Angner, E. (2012). *A Course in Behavioral Economics*. Palgrave Macmillan.

Angrisani, M., Guarino, A., Jehiel, P., & Kitagawa, T. (2021). Information Redundancy Neglect versus Overconfidence: A Social Learning Experiment. *American Economic Journal: Microeconomics*, *13*(3), 163–197. https://doi.org/10.1257/mic.20180394

Avram, L.-A. (2018). Gender Differences and Other Findings on the Cognitive Reflection Test. *Studia Universitatis Babes-Bolyai Oeconomica*, *63*(3), 56–67. https://doi.org/doi:10.2478/subboec-2018-0014

Banerjee, A. V. (1992). A Simple Model of Herd Behavior. *The Quarterly Journal of Economics*, *107*(3), 797–817. https://doi.org/10.2307/2118364

Besedeš, T., Deck, C., Sarangi, S., & Shor, M. (2012). Decision-making strategies and performance among seniors. *Journal of Economic Behavior & Organization*, *81*, 524–533. https://doi.org/10.1016/j.jebo.2011.07.016

Bikhchandani, S., Hirshleifer, D., Tamuz, O., & Welch, I. (2021). Information Cascades and Social Learning. *National Bureau of Economic Research Working Paper Series*, *No. 28887*. https://doi.org/10.3386/w28887

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

Boyer, B., Mitton, T., & Vorkink, K. (2010). Expected Idiosyncratic Skewness. *The Review of Financial Studies*, *23*(1), 169–202. https://doi.org/10.1093/rfs/hhp041

Brañas-Garza, P., Kujal, P., & Lenkei, B. (2019). Cognitive reflection test: Whom, how, when. *Journal of Behavioral and Experimental Economics*, *82*, 101455. https://doi.org/10.1016/j.socec.2019.101455

Brunner, C., & Goeree, J. K. (2009). Wise Crowds or Wise Minorities? *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1477942

Burton, E. T., & Shah, S. N. (2013). *Behavioral Finance: Understanding the social, cognitive, and economic debates*. Wiley.

Callander, S., & Hörner, J. (2009a). The wisdom of the minority. *Journal of Economic Theory*, *144*(4), 1421-1439.e2. https://doi.org/10.1016/j.jet.2009.02.001

Callander, S., & Hörner, J. (2009b). The wisdom of the minority. *Journal of Economic Theory*, *144*(4), Article 4. https://doi.org/10.1016/j.jet.2009.02.001

Campitelli, G., & Labollita, M. (2010). Correlations of cognitive reflection with judgments and choices. *Judgment and Decision Making*, *5*, 182–191. https://doi.org/10.1017/S1930297500001066

Çelen, B., & Hyndman, K. (2012). Social Learning Through Endogenous Information Acquisition: An Experiment. *Management Science*, *58*(8), 1525–1548. https://doi.org/10.1287/mnsc.1110.1506

Choi, S., Gale, D., & Kariv, S. (2012). Social learning in networks: A Quantal Response Equilibrium analysis of experimental data. *Review of Economic Design*, *16*(2–3), 135–157. https://doi.org/10.1007/s10058-012-0122-x

Dawson, J. F. (2014a). *Interpreting interaction effects*. Interpreting Interaction Effects. http://www.jeremydawson.co.uk/slopes.htm

Dawson, J. F. (2014b). Moderation in Management Research: What, Why, When, and How. *Journal of Business and Psychology*, *29*(1), 1–19. https://doi.org/10.1007/s10869-013-9308-7

Dourado, G. de A., & Tabak, B. M. (2013). *Teste da Hipótese de Mercados Adaptativos para o Brasil* (325; Trabalhos para Discussão, p. 53). Banco Central do Brasil. https://www.bcb.gov.br/pec/wps/port/TD325.pdf

Duffy, J., Hopkins, E., & Kornienko, T. (2021). Lone wolf or herd animal? Information choice and learning from others. *European Economic Review*, *134*, 103690. https://doi.org/10.1016/j.euroecorev.2021.103690

Duffy, J., Hopkins, E., Kornienko, T., & Ma, M. (2019). Information choice in a social learning experiment. *Games and Economic Behavior*, *118*, 295–315. https://doi.org/10.1016/j.geb.2019.06.008

Favero, L. P., & Belfiore, P. (2017). *Manual de Análise de Dados: Estatística e Modelagem Multivariada com Excel®, SPSS® e Stata®* (1ª edição). GEN LTC.

Festinger, L. (1957). *A Theory of Cognitive Dissonance* (Anniversary ed. edição). Stanford University Press.

Frederick, S. (2005a). Cognitive Reflection and Decision Making. *Journal of Economic Perspectives*, *19*(4), 25–42. https://doi.org/10.1257/089533005775196732

Frederick, S. (2005b). Cognitive Reflection and Decision Making. *Journal of Economic Perspectives*, *19*(4), Article 4. https://doi.org/10.1257/089533005775196732

Fromlet, H. (2001). Behavioral finance-theory and practical application. *Business Economics*, *36*(3), 63–69. Scopus.

Frydman, C., & Krajbich, I. (2022). Using Response Times to Infer Others' Private Information: An Application to Information Cascades. *Management Science*, *68*(4), 2970–2986. https://doi.org/10.1287/mnsc.2021.3994

Gilad, B., Kaish, S., & Loeb, P. D. (1987). Cognitive dissonance and utiliy maximization: A General Framework. *Journal of Economic Behavior & Organization*, *8*(1), 61–733. https://doi.org/10.1016/0167-2681(87)90021-7

Gippel, J. K. (2013). A revolution in finance? *Australian Journal of Management*, *38*(1), 125–146. https://doi.org/10.1177/0312896212461034

Goeree, J. K., & Yariv, L. (2015). Conformity in the lab. *Journal of the Economic Science Association*, *1*(1), 15–28. https://doi.org/10.1007/s40881-015-0001-7

Han, B., Hirshleifer, D., & Walden, J. (2018). *Social Transmission Bias and Investor Behavior* (Working Paper 24281; Working Paper Series). National Bureau of Economic Research. https://doi.org/10.3386/w24281

Han, B., Hirshleifer, D., & Walden, J. (2022). Social Transmission Bias and Investor Behavior. *Journal of Financial and Quantitative Analysis*, *57*(1), 390–412. https://doi.org/10.1017/S0022109021000077

Hayes, A. F. (2013). *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach* (Edição: First). Guilford Publications.

Hirshleifer, D. (2020a). Presidential Address: Social Transmission Bias in Economics and Finance. *The Journal of Finance*, *75*(4), 1779–1831. https://doi.org/10.1111/jofi.12906

Hirshleifer, D. (2020b). *Transcript of the AFA 2020 Presidential Address with Presentation Slides: Social Transmission Bias in Economics and Finance* (SSRN Scholarly Paper ID 3513201). Social Science Research Network. https://doi.org/10.2139/ssrn.3513201

Hirshleifer, D. (2020c). *Transcript of the AFA 2020 Presidential Address with Presentation Slides: Social Transmission Bias in Economics and Finance* (SSRN Scholarly Paper ID 3513201; Issue ID 3513201). Social Science Research Network. https://doi.org/10.2139/ssrn.3513201

Hirshleifer, D., & Teoh, S. H. (2009). Thought and Behavior Contagion in Capital Markets. In K. R. Shcenk-Hoppé (Ed.), *Handboof of Financial Makrets Dynamics* (1st ed., p. 591). Elsevier.

Hoppe, E. I., & Kusterer, D. J. (2011). Behavioral biases and cognitive reflection. *Economics Letters*, *110*(2), 97–100. https://doi.org/10.1016/j.econlet.2010.11.015

Jackson, M. O. (2009). Networks and Economic Behavior. *Annual Review of Economics*, *1*(1), 489–511. https://doi.org/10.1146/annurev.economics.050708.143238

Jensen, A. R. (1998). *The g Factor: The Science of Mental Ability* (First Edition). Praeger.

Kahneman, D. (2012). *Rápido e devagar* (C. de A. Leite, Trans.; Edição: 1ª). Objetiva.

Kahneman, D., & Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica*, *47*(2), 263–291. JSTOR. https://doi.org/10.2307/1914185

Kübler, D., & Weizsacker, G. (2004). Limited Depth of Reasoning and Failure of Cascade Formation in the Laboratory. *Review of Economic Studies*, *71*(2), 425–441. https://doi.org/10.1111/0034-6527.00290

Kuhn, T. S. (2017). *A Estrutura das revoluções científicas* (Edição: 13). Perspectiva.

Kumar, A. (2009). Who Gambles in the Stock Market? *The Journal of Finance*, *64*(4), 1889–1933. JSTOR.

Lakatos, I. (1979). O Falseamento e a Metodologia dos Programas de Pesquisa Científica. In I. Lakatos & A. Musgrave, *A crítica e o desenvolvimento do conhecimento* (pp. 109–243). Editora da Universidade de São Paulo.

Lo, A. W. (2005). Reconciling Efficient Markets with Behavioral Finance: The Adaptive Markets Hypothesis. *Journal of Investment Consulting*, *7*(2), 21–44.

Mayer, T. (2019, March 20). *The Discovering Markets Hypothesis (DMH)*. CFA Institute. https://blogs.cfainstitute.org/investor/2019/03/20/the-discovering-markets-hypothesis-dmh/

Mendonça, A. L. de O., & Videira, A. A. P. (2007). Progresso científico e incomensurabilidade em Thomas Kuhn. *Scientiae Studia*, *5*(2), 169–183. https://doi.org/10.1590/S1678-31662007000200003

Moritz, B. B., Hill, A. V., & Donohue, K. L. (2013). Individual differences in the newsvendor problem: Behavior and cognitive reflection. *Journal of Operations Management*, *31*(1), 72–85. https://doi.org/10.1016/j.jom.2012.11.006

Neyse, L., Bosworth, S., Ring, P., & Schmidt, U. (2016). Overconfidence, Incentives and Digit Ratio. *Scientific Reports*, *6*(1), Article 1. https://doi.org/10.1038/srep23294

Oechssler, J., Roider, A., & Schmitz, P. W. (2009). Cognitive abilities and behavioral biases. *Journal of Economic Behavior & Organization*, *72*, 147–152. https://doi.org/10.1016/j.jebo.2009.04.018

Otero, I., Salgado, J. F., & Moscoso, S. (2022). Cognitive reflection, cognitive intelligence, and cognitive abilities: A meta-analysis. *Intelligence*, *90*, 101614. https://doi.org/10.1016/j.intell.2021.101614

Oxoby, R. J. (2003). Attitudes and allocations: Status, cognitive dissonance, and the manipulation of attitudes. *Journal of Economic Behavior & Organization*, *52*(3), 365–385. https://doi.org/10.1016/S0167-2681(03)00027-1

Park, C. W., Gardner, M. P., & Thukral, V. K. (1988). Self-Perceived Knowledge: Some Effects on Information Processing for a Choice Task. *The American Journal of Psychology*, *101*(3), 401–424. https://doi.org/10.2307/1423087

Park, J., Konana, P., Gu, B., Kumar, A., & Raghunathan, R. (2013). Information Valuation and Confirmation Bias in Virtual Communities: Evidence from Stock Message Boards. *Information Systems Research*, *24*(4), 1050–1067. https://doi.org/10.1287/isre.2013.0492

Shleifer, A. (2004). *Inefficient Markets: An Introduction to Behavioral Finance*. Oxford University Press.

Silva, E. D., & Costa, R. S. (2019). Uma reflexão epistemológica sobre o status científico da administração sob a ótica dos critérios de demarcação científica de Popper, Kuhn e Lakatos. *Revista Ciências Administrativas*, *25*(3). https://doi.org/10.5020/2318-0722.2019.9660

Thaler, R. H. (1999). The End of Behavioral Finance. *Financial Analysts Journal*, *55*(6,), 12–17.

Weizsäcker, G. (2010). Do We Follow Others when We Should? A Simple Test of Rational Expectations. *American Economic Review*, *100*(5), 2340–2360. https://doi.org/10.1257/aer.100.5.2340

APPENDIX A – INITIAL INSTRUCTIONS FOR EXPERIMENT 1

Welcome to the Restaurant Game!

In this game, you are a tourist in a crowded city looking for a good restaurant.
In this city there are local people who already know which is the good restaurant.
You arrive at the food court and there are 2 restaurants for you to choose:
One of them is **good** and the other it is **bad**.

Your goal is to choose the good restaurant.
If you choose the **correct restaurant**, you will earn 10 points in the round.
If you choose the **wrong restaurant**, you will not receive points.

Also, the computer will **randomly might** give you an information with the **correct answer.**
That is, you can be chosen to know which restaurant it is the good one or not.
The probability of you receiving the answer is **p = 1/6 (1 out of 6)**.

If you do not receive the answer, you will have to look each situation and try to figure it out which is the good restaurant.
Keep in mind that **1/6 of people are locals** (with correct info) and the other **5/6 are tourists (including yourself)**.

In each round, your order to play will also be randomly defined (you can be the 1st, 2nd, 3rd, 4th, 5th or 6th people to choose the restaurant).
Before making your decision, you will see a total number of people (locals and tourists) who are eating inside each restaurant and arrived before you.

Your individual score is neither added nor shared with anyone.
After your response has been validated, you will receive a **payment based on your final score**.
You will play for 16 rounds.

Shall we begin?

APPENDIX B – CRT QUESTIONS AND ANSWERS

1. If 3 elves can wrap 3 toys in 1 hour, how many elves does it take to wrap 6 toys in 2 hours?
   a. Correct answer: 3 elves;
   b. Intuitive and incorrect answer: 6 elves.

2. On a running team, tall members won 3x more medals than short members. This year, the team won a total of 60 medals. How many of them were won by shorter athletes?
   a. Correct answer: 15 medals;
   b. Intuitive and incorrect answer: 20 medals.

3. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? (Type only numbers)
   a. Correct answer: 47 days;
   b. Intuitive and incorrect answer: 24 days.

APPENDIX C – SOCIODEMOGRAPHIC QUESTIONNAIRE

1. How old are you?
2. What is your gender?
    a. Female;
    b. Male;
    c. Other.
3. What is your ethnic group?
    a. White;
    b. Black or African American;
    c. Indigenous;
    d. Asian;
    e. Other.
4. What is your marital status?
    a. Single (never married);
    b. Living with a partner;
    c. Married;
    d. Divorced;
    e. Widowed.
5. What is the highest degree or level of school you have completed?
    a. Some elementary school;
    b. Elementary school;
    c. Some High school;
    d. High school;
    e. Some bachelor’s degree;
    f. Bachelor’s Degree;
    g. Master’s or Ph.D. Degree.
6. If you finished college, what is your bachelor’s degree?
7. What is your employment stats?
    a. Full-time;
    b. Part-time;
    c. Unemployed;
    d. Retired.
8. Which of the following best describes your personal income last year?
    a. $0-9,999
    b. $10,000-$24,999
    c. $25,000-$49,999
    d. $50,000-$74,999
    e. $75,000-$99,999
    f. Above $100,000
    g. Prefer not to answer.

APPENDIX D – INITIAL INSTRUCTIONS FOR EXPERIMENT 2

In this game, imagine yourself as a tourist in a crowded city looking for a good restaurant. You arrive at the food court and there are 2 restaurants for you to choose from: restaurant A and restaurant B.
One of the restaurants is **good,** and the other is **bad**, but initially you don't know which is which.

Your goal is to select the good restaurant.
If you choose the **good restaurant**, you will earn **10 points** in the round.
If you choose the **bad restaurant**, you will not receive any points.

You are part of a group of 6 players (you and 5 others). In each round, you and the other players will sequentially choose whether to go to restaurant A or restaurant B.
Before each round you are going to receive a signal. This signal is a recommendation given to you by the computer regarding which restaurant it believes is the good one.

This signal can be of 2 types: **silver** or **gold**.
The **silver** signal has a 60% level of precision. This means that its recommendation will be correct with a probability of **60%**.
The **gold** signal has a 90% level of precision. This means that its recommendation will be correct with a probability of **90%**.
At each round, only one of the 6 players will receive a **gold** signal. All other players will receive a **silver** signal.
The computer will **randomly choose** which player will receive the **gold** signal each round.

Therefore, if you receive a **gold** signal, you know that all the other five players have received a **silver** signal.
And if you receive a **silver** signal, you know that among the five other players, one of them received a **gold** signal and the other four players a **silver** signal like yours.

When it is your turn to make a decision, you must choose the restaurant you believe is more likely to be the **good** one. Each round, the computer randomly chooses which of the two restaurants is the **good** one.

Keep in mind that in each round **1 person has a gold signal** and the other **5 have a silver signal.**

Each round, your order of play will also be randomly defined by the computer (you can be the 1st, 2nd, 3rd, 4th, 5th or 6th person to choose a restaurant). Congestion is not an issue in this game. Regardless of how many players choose the correct restaurant, everyone who chose correctly receives 10 points.

When it's your turn, before making a decision, you will also receive information about the total number of people who chose restaurant A and restaurant B. For instance, suppose the computer selected you to be the 4th person in the sequence this round. You already know the type of signal you received and its recommendation to you. But now you will also receive information about how many people who moved before you chose each restaurant. You might receive the information that 2 people chose restaurant A and 1 person chose restaurant B, for example. Based on this information and the recommendation you received from the signal, you must choose which restaurant to visit. Remember, your goal is to select the restaurant you believe is more likely to be the good one to maximize your chances of earning 10 points in each round.

You will be paid at the end of the experiment based on the total points accumulated at the end of 16 rounds (your final individual score).

Shall we begin?

APPENDIX E – MINORITY WISDOM PROBABILITIES DECISION TREE