

## THE HOUSE-MONEY EFFECT, ESCALATION OF COMMITMENT AND TESTOSTERONE (2D:4D RATIO): AN EXPERIMENTAL APPROACH

Anderson M. Teixeira<sup>1</sup>  
Benjamin M. Tabak<sup>2</sup> Daniel O. Cajueiro<sup>3</sup>

### Área 8 - Microeconomia, Métodos Quantitativos e Finanças

**Resumo:** Este artigo investiga a relação entre o marcador biológico 2D:4D e a concepção psicológica do *house-money-effect* (HME). Entre os resultados obtidos não foi possível constatar que os voluntários apresentam um comportamento consoante ao postulado pela hipótese da *house-money effect* e *escalation of commitment* em ambos os sexos. Os resultados do experimento, corroboram a hipótese de que, para voluntários de ambos os sexos, com menor razão 2D:4D apostaram mais após um ganho e também após uma perda. Esse resultado está de acordo com a sugestão da literatura do (HME) e do marcador biológico, ou seja, voluntários com maior exposição ao hormônio testosterona investem mais, tendo em vista que são menos avessos ao risco. Em relação à análise de robustez os resultados indicaram que o marcador biológico 2D:4D foi um preditor significativo para a diferença de comportamento entre homens e mulheres.

**Palavras-chave:** Risco, Experimento, Testosterona. **JEL Classification:**C9, D81

**Abstract:** This paper investigates the relationship between the 2D:4D biological marker and the psychological conception of house-money-effect (HME). Among the results obtained it was not possible to verify that the volunteers present a behavior according to the hypothesis of the House Money Effect hypothesis and escalation of commitment in both sexes. The results of the experiment, however, corroborate the hypothesis that, for volunteers with lower 2D:4D ratios, they bet more after a gain and also after a loss. This result is in agreement with the suggestion of the literature of (HME) and the biological marker, that is, volunteers with greater exposure to the hormone testosterone invest more, considering that they are less risk-averse. Regarding the robustness analysis the results indicated that the 2D: 4D biological marker was a significant predictor for the difference in behavior between men and women.

**keywords:** Risk, Experiment, Testosterone. **JEL Classification:**C9, D81

## 1 INTRODUCTION

One of the most relevant themes in economic theory is understanding the decision-making and judgment processes in human beings. In these everyday decisions the decision-maker is not quite sure what the consequence or result of a certain choice will be. This is because, given the choice that need to made daily, the decision-maker is in fact behaving as if s/he were betting in a lottery, whose result is linked to the state of nature. (Teixeira, 2013).

Numerous situations may exemplify this phenomenon, such as the purchase of a used car, financial investments, the contracting of health or car insurance, horse races, lotteries and casinos, among many others.

<sup>1</sup> UFG-FACE, Universidade Federal de Goiás, Programa de Pós Graduação em Economia (PPE), Goiânia, Goiás, Brasil.

<sup>2</sup> Fundação Getúlio Vargas - FGV. Escola de Políticas Públicas e Governo, Brasília, DF, Brasil.

<sup>3</sup> Departamento de Economia, Universidade de Brasília, FACE, Brasília, DF, Brasil.

In this context, in recent years a series of studies has been attempting to understand the nature of human behavior, not only from a cognitive perspective (behavioral economics), but also considering biological factors and their connection with certain personality traits both in men and women. In these studies, the main biological factor investigated was exposure to the hormone testosterone in the uterus, by way of a proxy for the 2D:4D ratio biological marker.

Researchers working on this new theoretical front indicate that higher exposure to testosterone in the uterus may be inferred when 2D (index finger) is lower than 4D (ring finger), and is an indicator of many personality traits that will develop over the lifetime of a human being.

According to these hypotheses, lower 2D:4D ratios in both genders is associated with the following personality traits: higher fertility, good health, greater ability in sports and music, competition and dominance, less fear, greater aggressiveness, and a higher inclination towards risks and gambling. In this context, recent research suggest that the difference in behavior between genders, regarding economic issues such as the aversion to risk and competition, may be partially explained by the higher exposure to the hormone testosterone. (Manning et al.(1998), MCIntyre, (2006) and Cohen-Bendahan et al.(2005) and Könekopp et al. (2007, 2010).

Therefore, the aim of this article was to gather experimental evidence on whether greater exposure to the hormone testosterone (lower 2D:4D ratio) influences decision-making among the genders, particularly with regard to the cognitive bias known as the House-Money Effect (HME) and Escalation of Commitment. In addition to this introduction, the article is organized into 8 sections. In the following section, the theory and certain empirical evidence related to the hormone testosterone and risk are presented. Section 3 discusses the House Money Effect (HME) and Escalation of Commitment behavioral bias. In section four, we discuss the experimental hypothesis. In section 5, the experimental procedure is described. In section 6, the results. In section 7, the concluding remarks and lastly, in section 8, the complementary material.

## **2 THE HORMONE TESTOSTERONE: THEORETICAL FRAMEWORK AND EXPERIMENTAL EVIDENCE**

According to Garbarino et al.(2011), androgens are hormones that play a fundamental role in the human brain and behavior, due to organizational and transitory effects. The organizational effect takes place during brain development, while the transitory effect occurs over a given lifetime, with the circulation of the hormone activating personality traits inherent to human behavior.

In this context, several areas of knowledge have sought to explain the relation between biological factors and behavior traits resulting from the exposure to the hormone testosterone. The seminal work done Manning et al. (1998) produced evidence of the relation between said hormone and certain traits of human behavior. For being less invasive, 2D:4D was determined as the biological marker indicating greater exposure to the hormone testosterone in the uterus (MCIntyre, 2006) and Cohen-Bendahan et al.(2005).

The studies of Manning et al (1998), Manning (2002), Lutchmaya et al (2004), Putz et al (2004), McIntyre (2006), and Könekopp et al (2007; 2010) defined the marker of exposure to the hormone testosterone in the uterus as the ratio between the length the index finger (2D) and the ring finger (4D) of the hands.

Consequently, the lower the 2D:4D ratio, i.e., the index finger (2D) is shorter than the ring finger (4D), the higher exposure to said hormone in the uterus. Therefore, it may be concluded that there is a direct relation between the lower ratio of the fingers of the hand and the higher level of exposure to the hormone testosterone (Manning et al. 1998).

Manning et al. (1998) confirmed the existence of a sexual dimorphic standard for the genders where the ratio for both the left and right hands in men was 0.98, indicating the (4D) ring finger as not as long as the index (2D). This result was different for females whose ratio was 1.00 for both hands. McIntyre (2006) and Könekopp et al. (2007, 2010) also confirmed the validity of the proxy as a biological marker of exposure to the hormone testosterone in the uterus.

With the confirmation of the 2D:4D ratio as a proxy for exposure to the hormone testosterone in the uterus, several studies have been conducted aiming to investigate various traits and cognitive behaviors between the genders. In this regard, a lower ratio in either sex is associated with higher fertility (Manning et al. 1998), good health (Manning et al. 2002), greater sporting and musical abilities (Manning et al. 2001;2002), competition and dominance (Archer, 2006), less fear, (Hermans et al. 2006) aggressiveness (Bailey et al. 2005), (Archer 2005) and (Hampson et al. 2008), higher inclination towards gambling and the consumption of alcoholic beverages (Blanco et al. 2001).

In this context, recent studies suggest that the difference in behavior between the sexes, in relation to economic issues, such as aversion to risk and competition, may be partially explained by exposure to the hormone testosterone. The main research in this new area of study includes Coates and Herbert (2008), Apicella et al. (2008), Sapienza et al. (2009), Coates et al. (2009), Garbarino et al. (2011), Garza and Rustichini (2011), Pearson and Shipper (2012), and Da Silva et al. (2013) and Teixeira et. al (2015). All generally confirm the influence of greater exposure to the hormone testosterone in the decision-making processes of economic agents.

### **3 HOUSE-MONEY EFFECT AND ESCALATION OF COMMITMENT: THE ROLE OF PREVIOUS RESULTS IN DECISION-MAKING**

In what way are subsequent choices made by agents affected by gains and/or losses in economic settings? An answer to this question was proposed by the classic studies of Staw (1976), Thaler and Johnson (1990), and Brockner (1992). To illustrate the idea of the authors, imagine an economics researcher is attending the SBE<sup>4</sup> in Foz do Iguazu (PR-Brazil), and after having dinner with friends decides to prolong the night and head to some casinos on the Argentine side of the border.

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<sup>4</sup> Brazilian Econometrics Society.

In this context, when passing by a gambling machine the person decides to bet a \$0.50 centavo coin, and surprisingly wins \$100 Argentine pesos. How will he or she behave during the rest of the night at the casino? Now imagine the same researcher, after a tiresome article presentation session, goes to the hotel's pool area to take a swim and have a few beers with some peers and, when it comes time to pay the bill, discovers that R\$100,00 is missing from his or her wallet. Once again, this will have an effect on his or her behavior during the rest of the day<sup>5</sup>.

According to Thaler and Johnson (1990), in sequence games with unlimited rounds agents will be less averse to risk when there is a prior gain. In other words, individuals will be less sensitive to losses as a result of the prior gains. In the finance behavior literature, this effect is known as the House-Money Effect (HME).

Given that prior gains reduce aversion to risk, Thaler and Johnson (1990) developed the Quasi-Hedonic Editing Theory (QHE). To do this, they resorted to the Prospect Theory, which establishes a two-phase distinction in agents' choice processes. In the first, called Editing, the individual performs a preliminary assessment of prospects, and creates a set of the most simple gain and/or loss combinations. In the second phase, called Assessment, based on the prospective combinations in the Editing phase, the individual assesses and selects the set of greater value. Given these two phases, how are previous results condensed in the Editing phase?

For Thaler and Johnson (1990, p.645) it is possible to understand the role of prior gains and losses, since “(...) *there is some flexibility in how prospects are edited, particularly when a priori outcomes might influence the reference point*”. The above mentioned authors subsequently proposed an alternative rule for the editing of prospects. According to the QHE rule, the losses of agents are not that relevant, since prior gains induce lower aversion to risk in subsequent periods.

On the other hand, prior losses may not be automatically canceled out, particularly when the outcome of the subsequent round does not offer a break even opportunity, i.e., when a gain does not compensate prior losses.

However, according to Staw (1976) and Brockner (1992), prior losses may not be treated in isolation, and must be assessed according to a psychological concept called escalation of commitment. This concept reflects greater propensity towards risk even in light of prior losses. The theoretical explanation for this psychological concept may be found in three theories: a) Self-Justification, b) Prospect Theory and; c) Gambles Fallacy.

According to Staw (1976), in Self-Justification an individual will bet a higher amount in the subsequent round, since he or she does not admit error in prior decisions, and rationally justify the errors based on their beliefs.

For Kahneman and Tversky (1979), Brockner (1992), and Lam and Ozorio (2013) based on Kahneman and Tversky (1979), in the Prospect Theory more money will be allocated in subsequent gambles, since lower aversion to losses justifies a higher bet so that money lost in the prior round may be recovered.

Lastly, Clotfelter and Cook (1993), in the Gambler's Fallacy, hold that gamblers believe

<sup>5</sup> These cases are mere illustrations adapted from Thaler and Johnson (1990, p.643).

that some particular outcome, that has not yet occurred, will occur in the future. Therefore, they will increase their bets in subsequent rounds on the belief that prior losses will increase the chance of future gains<sup>6</sup>.

### 3.1 EMPIRICAL EVIDENCE OF THE HOUSE-MONEY EFFECT AND ESCALATION OF COMMITMENT

A large number of studies have provided empirical support to the theoretical concepts outlined above, namely the influence of prior gains and/or losses on future gambling behavior.

Fernandes et.al (2006) performed an experiment based on slight modifications to the work of Haigh and List (2005). The study was conducted with volunteers from both Brazil and Spain, testing whether prior gains and/or losses interfere in subsequent decisions.

Fernandes et.al (2006) introduced some changes to the treatment groups, subsequently called treatment I and treatment C. The volunteers in the treatment I group received the sum of 100 monetary units, part of which could be gambled on financial lottery. This treatment is similar to that of the control group H proposed by Gneezy and Potters (1997).

In the treatment C group, in each odd-numbered round (1,3,5,7,9 and 11) volunteers received 100 monetary units, also betting part of this amount. In the even-numbered round (2,4,6,8,10 and 12) volunteers gambled part of the initial amount in addition to the gain accrued in the previous round. Thus, volunteers considered prior gain and/or loss outcomes. The idea was to observe the behavior of gamblers in the subsequent round to capture the house-money effect.

The results obtained by Fernandes et.al (2006) refuted the house-money effect since the participants in the treatment C group gambled a higher share of the amount given when losing in the previous round as opposed to a gain.

Similarly, Lam and Ozorio (2013) assessed the role of gains and losses in subsequent choices made by the genders. The working hypotheses tested were the following: (1) whether men with financial gains in previous rounds tend to increase their propensity to risk in subsequent lotteries, and; (2) whether women with financial losses in previous rounds tend to increase the propensity to risk in subsequent lotteries.

These hypotheses were verified in an experiment involving the participation of 3 different groups of volunteers. The first group, called RP, was comprised of executives working in the casinos of Macao (China). The second group, called RC, was comprised of volunteers who regularly went to casinos in the same city. And the third and last group, called NRC, was comprised of volunteers who never went to a casino.

The results obtained by the authors suggest that, in the case of men of the RC group, the average amount bet was higher after a gain, while for women the average amount bet was higher after a loss. The behavior was also detected for the NRC group, with men converging towards

<sup>6</sup> For further details, see: Gamblers Fallacy, Notes: The 'Gambler's fallacy' in lottery play. Management Science 39, n. 12: 1521-5.

the house-money effect, while women's behavior followed the escalation of commitment. Lastly, no statistical significance was found between genders for the RP group.

Other studies testing both hypotheses were carried out by Weber and Zuchel (2005), Coval and Shumway (2005), Frino et.al (2008), Liu et.al (2010), and Hsu et.al (2013). All said studies involved financial market traders. The main results obtained corroborated the house-money effect<sup>7</sup>.

#### **4 HYPOTHESIS OF THE EXPERIMENT**

Aiming to test the relation between HME and the 2D:4D biological marker, the Fernandes et.al (2006) experiment was replicated. Here, the following hypothesis were tested:

1. If men and women with lower 2D:4D ratios (suggesting a high level of exposure to the hormone testosterone in the uterus) presented behavior consistent with the house-money effect (HME);
2. If men and women with lower 2D:4D ratios invest more after a gain;
3. If men and women with lower 2D:4D ratios (suggesting a high level of exposure to the hormone testosterone in the uterus) present behavior consistent with the escalation of commitment concept;
4. If men and women with lower 2D:4D ratios invest more after a loss;
5. If the 2D:4D ratio is a significant predictor to understand the gap between men and women in relation to HME within a group or between genders.

#### **5 THE EXPERIMENTAL PROCEDURE**

The biological potential of higher exposure to the hormone testosterone interferes in the decision-making of economic agents. The influence of the hormone on the behavior of economic agents regarding their choices involving risk may be measured by a proxy called 2D:4D. In this regard, scanned copies of both the left and right hands of the volunteers were made. Second copies were also made in the event the first copies were not clear, and volunteers were also requested to remove any rings or jewelry from their fingers. It must be pointed out that the procedure with the 2D:4D proxy was the same for the three experiments conducted.

Each copy was identified with the same lottery number (registry) registered by the volunteer. The scanner used was the HP Scanjet G4050, with a digital resolution of up to 4800 x 9600 dpi. In addition, the scanned copies were measured with the AutoMetric 2.2 software package developed by DeBruine (2004), so as to obtain the exact measurements of the index (2D) and ring fingers (4D).

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<sup>7</sup> See also Grou and Tabak (2008).

For the experiment, undergraduate students from the Federal University of Goiás (UFG) were recruited.<sup>8</sup> The experiments were carried out on 24 computers in room 104 of Classroom Center B (Baru) of the same institution. Proceeding in this manner, participant error and weariness was avoided with the use of a specific software.<sup>9</sup> The process was streamlined so that while participants decided the amounts to be bet in the financial lottery, the software registered the amounts actually bet, the time taken to make decisions per lottery, the gains in each round, the amounts accrued during the experiment, all according to the rules of each treatment group.

Two interleaved sessions per round were held between the treatment and the control group for both experiments. By doing so, we aimed to reduce the exchange of information between participants and non-participants. Five volunteers participated in the shorter experimental session, and 24 participated in the longer session. A total of 6 sessions were held, four for the treatments HME-IR, and two for the HME-C.

The duration of the experiment depended on the number of participants per session, lasting 55 minutes on average, with 20 min given to read the instructions, to demonstrate the example projected on a screen, to fill out a questionnaire on certain biological and social information, and the making of the bets. The remaining time was used to take the photocopies of both hands, to gather the signatures of the terms of consent, and to randomly choose the winners. Doubts, when they arose, were addressed individually.

Leaflets were handed out throughout Classroom Center B and at cafeterias on the University campus requesting volunteers. The leaflets indicated the days and times established for participation in the scientific study, and offered the chance of winning up to R\$ 21.00 (twenty one reais). Also issued were special leaflets for the two sessions of the House-Money Effect (HME-C) treatment, indicating the chance of winnings of up to R\$ 90.00 (ninety reais<sup>10</sup>).

Given budgetary restrictions, show up fees were not offered to participants, but a suggestion was made to professors in the Economics, Business Management and Accounting departments to offer an extra 5 points on tests to those participating.

## 5.1 SPECIFIC PROCEDURE

The experiment conducted was a replication of the work of Fernandes et.al (2006). The aim was to capture the behavior of economic agents in light of the gains and/or losses obtained in previous rounds. In Fernandes et.al (2006), volunteers were divided into two groups.

1. Participants of the IR Group (Isolated result): followed the same rule for Group H of the Gneezy and Potters (1997), and Teixeira et.al (2015) MLA experiment.

<sup>8</sup> The experiment was approved by the UnB Ethic Committee. UnB, CEP - IH. CAAE. 13140713.6.0000.5540.

<sup>9</sup> The programs used were developed by Marcus Vinícius Nascimento, who may be contacted by email at marckyn@gmail.com.

<sup>10</sup> Due to budgetary restrictions regarding this treatment, two sessions were held using the maximum capacity of the IT laboratory, which was 24 computers for a total sample of 48 volunteers.

2. Participants of Group C (Accumulated result): the experiment comprised 12 consecutive rounds of the same lottery, the first being a test and not worth anything. In round 1, volunteers received 100 monetary units and decided how much of this amount to gamble in the lottery. In subsequent rounds, the volunteers once again decided how much of the 100 monetary units to gamble in addition to the gains accrued previously (previous round) in the following lottery:

- **You have two-thirds of a chance (67%) of losing the amount you bet, and one-third (33%) of winning 2.5 times the amount bet.**

The experiment took place over 12 rounds, where volunteers were aware of the previous gain/loss results which generated the mechanism needed to observe their reaction towards the next lottery (t+i), thus capturing the house-money-effect and also the escalation of commitment.

As in the experimental procedure of Gneezy and Potters (1997), in Teixeira et.al (2015) in each round volunteers would decide the amount to be bet, and the gains and losses of a given lottery depended on the registry letter chosen from among three alternatives, A, B or C.

Thus, if the volunteer chose letter C, then this would be his or her registry letter for the experiment, and would also be a winner if the letter chosen randomly by the program were the same as the registry letter. It must be remembered that each registry letter had the same 33

Regarding the gains to be distributed in the experiment, once again every two monetary units represented one centavo of a Real. Volunteers began with 100 monetary units, which corresponded to 50 centavos of a Real (R0.50),

Analogous to the Gneezy and Potters (1997), and Teixeira et.al (2015) MLA experiment, if a volunteer bet 100 monetary units and his or her registry were drawn, the gain would be a total of 350 monetary units, since by winning he or she would receive 2.5 times the amount bet, in addition to the initial 100 monetary units. In the case of a loss, the volunteer would have 0 monetary units, but would have 100 monetary units in the following round.

## 6 RESULTS

A total of 98 volunteers participated in the HME experiment: 50 participants in HME-IR, and 48 in the HME-C treatment. In the HME-IR treatment, 32 males and 18 females participated, while in the HME-C treatment, male participation was 30 volunteers, and female 18 volunteers.

One important result was the measuring of the 2D:4D biological marker. In accordance with standard procedure described in the literature, the measurement of the right hand and the average of both hands were used to determine differences in the biological markers between the genders.

In effect, the difference in the 2D:4D ration was not significant for either treatment, for both the right hand and the average of both hands. For the HME IR treatment, the 2D:4D ratio for females was 0.9946, and for men 0.9830 ( $t = 0.8237$ ,  $p = 0.4142$ ). For the average of both



hands, women had an average value of 0.9888, while for men it was 0.9807 ( $t = 0.6559$ ,  $p = 0.515$ ).

For the HME-C, the average 2D:4D ratio of the right hand in women was 0.9728, while in men it was 0.9720 ( $t = 0.0709$ ,  $p = 0.9438$ ). The average for both hands in females was 0.9812 and in males 0.9741 ( $t = 0.7015$ ,  $p = 0.4865$ ). In spite of the statistical non-significance of the difference between genders, it must be pointed out that the average value for women was within the average range found in the literature, while for men it was slightly above-average<sup>11</sup>.

In order to investigate the role of greater exposure to the hormone testosterone and the house-money effect (HME), a comparison was made between the average amount bet among the volunteers with a higher ratio and the average amount bet by those with lower ratios.

### 6.1 2D:4D AND HME: INVESTIGATION OF BOTH GENDERS

The results of the influence of greater exposure to the hormone testosterone and HME, for both genders, were obtained by separating the sampling space of the HME-IR and HME-C treatment of participants with lower 2D:4D ratios (average less than 1) and participants with higher 2D:4D ratios (greater than 1). Table 1 shows the average amount bet by volunteers (both genders) with higher ratios (suggesting lower exposure to the hormone testosterone) and those with lower ratios (suggesting higher exposure to the hormone testosterone)

Table 1. Average amount bet in Groups HME-IR and HME-C (both genders) by volunteers with higher 2D:4D and lower 2D:4D.

	Higher 2D:4D		Lower 2D:4D	
	After Loss	After Gain	After Loss	After Gain
HME-IR	41,93 (15,56)	41,83 (23,81)	61,31 (21,63)	54,65 (25,88)
HME-C	124,63 (70,53)	131,78 (107,76)	153,30 (89,63)	183,64 (168,60)

<sup>11</sup> Standard deviation in parentheses.

The average wager values presented in Table 1 for volunteers of both genders with higher ratios in the HME-IR group indicate that, on average, they invested 41.93 monetary units per round, after the occurrence of a loss. This value was slightly higher than the average value bet after a gain, which was 41.83 monetary units.

However, in the HME-C group, volunteers invested 124.63 monetary units on average after a loss, and a significantly higher value of 131.78 after a gain. These values indicate, for the HMEIR group, an escalation of commitment, suggesting lower aversion to risk after a loss. On the other hand, for the HME-C group, data show behavior that reflects the house-money effect, indicating that volunteers invested higher amounts after a gain.

<sup>11</sup> The average values in the literature for women ranged between 0.96 and 0.99, while for men the average value was between 0.93 and 0.97 (Manning et al. 1998), McIntyre (2006) and Garbarino et.al (2011).

Among volunteers with lower ratios in the HME-IR group the average amount bet after a loss was 61.31 units. This average value is higher than the average amount invested after a gain, which was 54.65 monetary units. Similarly, for the HME-C group, the average amount bet was 153,30 monetary units after a loss, an amount lower than that bet after a gain, which was 183.64 on average. In light of this data, among volunteers with lower ratios in the HME-IR group, the results indicate the predominance of the escalation of commitment effect, but among those in the HME-C group, the house-money effect predominates.

The statistical confirmation of these results must nevertheless be tested by comparing them with the average amounts bet in the Mann-Whitney test. Table 2 summarizes the p-values of the Mann-Whitney test.

Table 2. P- Value of the Mann-Whitney test for differences between averages (both genders) of volunteers with higher 2D:4D in relation to those with lower 2D:4D.

	Higher 2D:4D	Lower 2D:4D
	After Loss vs After Gain	After Loss vs After Gain
HME-IR	0.9638	0.8815
HME-C	0.7969	0.8815

The result for the comparison of the average amounts bet in the HME-IR for volunteers of either gender with higher 2D:4D ratios was not statistically significant. Therefore, we did not reject the null hypothesis that held that the averages were equal. Thus, it was not possible to confirm whether the escalation of commitment predominant among volunteers of said treatment.

For the HME-C treatment, the test of the averages was not statistically significant. Despite the apparent difference between the average amounts bet, the null hypothesis was not rejected, according to which the averages were equal. Consequently, it was not possible to statistically confirm the predominance of the house-money effect after a gain for volunteers of this treatment group.

Although the predominance of the house-money effect was not confirmed for volunteers with lower ratios in the HME-C treatment, nor for escalation of commitment in the HME-IR treatment, the following exercise aimed to compare the average amount bet by volunteers with lower ratios in comparison with volunteers with higher ratios. The following question was expected to be answered by this exercise:

- Do volunteers of both genders with lower 2D:4D ratios invest higher average amounts in both HME-IR and HME-C treatments for situations involving prior losses as well as for those involving prior gains?

The groups After Loss1 and After Gain1 were created for the average value bet by volunteers of both genders with higher ratios, and the After Loss2 and After Gain2 groups for the average amounts bet by volunteers of both gender with lower ratios. The results are presented in Table 3 below.

Table 3. P – value of the Mann-Whitney test for differences in average amounts bet for both genders with higher 2D:4D ratios in comparison with volunteers of both genders with lower 2D:4D.

	After Loss1 vs After Loss2	After Gain1 vs After Gain2
HME-IR	0.00149***	0.008936***
HME-C	0.5548	0.3771

<sup>1</sup>\*\*\*Statistical significance 1%

The results of the comparison of the average amounts bet after a loss among volunteers with higher ratios in the relation to those with lower ratios in the HME-IR were statistically significant on the 1% level of significance. This rejects the hypothesis in which the average amounts bet are equal. In light of this, it may be inferred that volunteers with lower 2D:4D ratios invest higher amounts after a loss than those with higher 2D:4D ratios.

Along the same line, the comparison between the average amounts bet after a gain are also statistically significant at 1% and therefore the hypothesis that the averages are equal may be rejected. In other words, the results suggest that higher exposure to the hormone testosterone influenced the higher propensity towards risk, and thus corroborates a higher aversion to risk both after a loss as well as after a gain.

In relation to the HME-C group, the results were not statistically significant, and thus it was not possible to reject the null hypothesis according to which the averages are the same, in spite of the difference between the averages being apparently high.

## 6.2 ROBUSTNESS ANALYSIS FOR THE BIOLOGICAL MARKER AND THE HME

In this section, we present the results of the robustness analysis of the data for the HME experiment. Our concern was to verify whether the results obtained were biased, in light of the presence of other biological variables, such as weight and height, gender, race, and whether the volunteer is left- or right-handed. In order to this, we first performed the logarithmic transformation of the variables average amount bet and biological marker 2D:4D. With this transformation, the variables may be considered elasticities, thus facilitating interpretation. Therefore, a Minimum Ordinary Square OLS was calculated as follows:

$$V_i = \alpha_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \mu_i \quad (1)$$

Onde:

$V_i$  is the average amount bet in both HME treatments for both genders;  $X_1 = 2D:4D$  measure;  $X_2 =$  dummy variable for gender, 1 for males and 0 for females;  $X_3 =$  dummy variable for race, 1 for white and 0 for non-white;  $X_4 =$  dummy variable for left-/right-handed (laterality);  $X_5 =$  height;  $X_6 =$  weight e  $\mu_1$  the error term. Based on the variables to be estimated, Table 4 summarizes the results of the MOS regression with robust errors.

Table 4. MQO estimates for the HME experiment (HME-IR and HME-C)

	(1)	(2)
Constant	4,215** (0,07601)	3,292* (1,759)
l.2D:4D Right	-3,849** (1,629)	-4,167** (1,632)
dummy-gender		0,1378 (0,2118)
dummy-white		-0,2324* (0,1343)
Height		0,7752 (1,139)
Weight		-0.009429 (0,007199)
dummy-laterality		0,2991 (0,2304)
N	97	97
lnL	-95,91	-92,92

<sup>1</sup>Standard deviation in parentheses.

<sup>1\*\*</sup>Statistical significance 5%

<sup>2\*</sup>Statistical significance 10%

The data in column 1 summarize the inferences obtained from the correlation between the 2D:4D marker and the average amount bet and, as expected, the sign of the 2D:4D marker parameter was negative, in agreement with the work of Coates et.al (2009), Brañas-Garza and Rustichini (2011), Garbarino et.al (2011), and Teixeira et.al (2015). Therefore, this result confirmed the robustness of the biological marker and suggest an inverse relation between exposure to the hormone testosterone and the average amount bet. At the 5% level of significance, a 1% decrease in the 2D:4D ratio (suggesting higher exposure to the hormone testosterone) is associated to a 3.8% increase in the amount bet by the volunteer or in the aversion to risk. On the other hand, since the data are aggregated for values both after a gain or loss, we detected an 3,8% increase in the amount bet both after a loss or after a gain.

The central concern for the results in column 2 is whether the results obtained for the significance and robustness of the biological marker are biased due to the omitted variables, such as weight and height as suggested by Garbarino et.al (2011). In addition, according to the analysis made by Teixeira et.al (2015), other biological variables were included: a dummy for gender, race, and left- or right-handedness.

We were again able to determine that the biological marker was significant at the 5% level, but there was a slight increase in the impact of the biological marker. With the inclusion of other biological markers, a 1% reduction in the 2D:4D ratio (suggesting high exposure to the hormone testosterone) implicated a 4.1% increase in the amount invested.

Once again, in relation to the gender dummy variable, it was not possible to infer a difference in the average amount bet between men and women. Together with the result of the variable gender, it was also not possible to determine any difference between the amounts bet by left- and right-handed individuals, nor for the variables weight and height, given the statistical insignificance of the variables.

Therefore, the results are consistent with those obtained by Garbarino et.al (2011) for weight and height. At the 5% level of significance, there was a significant difference between the values bet by whites and non-whites, which were 22.25% lower for participants declaring being white. This result is relevant since it expresses ethnic heterogeneity in the treatment.

## **7 CONCLUDING REMARKS**

This study investigated the relation between the 2D:4D biological marker and the psychological concept called house-money-effect (HME) by replicating the experiment performed by Fernandes et al. (2006). From the results obtained, it was not possible to determine whether the volunteers presented behavior consistent with the House Money Effect nor the escalation of commitment concepts for either gender.

The results of the experiment did, however, corroborate the hypothesis that both men and women volunteers with lower ratios bet more both after a gain as well as a loss in the HME-IR treatment, in spite of the HME-C treatment not being statistically significant. This result is in agreement with the mention of the biological marker in the literature, i.e., volunteer with higher exposure to the hormone testosterone invest more, considering that they are less averse to risk.

In relation to the robustness analysis, the results indicated that the 2D:4D biological marker was a significant predictor of the difference in behavior between men and women. However, this was determined for the analysis involving both treatments (HME-IR and HME-C).

## **8 APPENDIX SUPPLEMENTARY MATERIAL**

The annexes related to the experiment.

### **8.1 1.SPECIFIC INSTRUCTIONS: HME-IR**

Thank you for participating in the choice under uncertainty experiment (decision-making). Please read carefully the instructions of the experiment. Kindly do not communicate in any way with the other volunteers and, during the experiment, turn off your cell phone, iPad, or any other communication device.

Do not look at the choices made by the other participants so that you do not influence the choices made by the other participants and that theirs do not influence yours. If you have any doubts, raise your hand and the monitor will answer your question individually.

The experiment is comprised of three stages. In the first stage, you will respond to a questionnaire with questions on certain biological and social traits. In the second stage, you will

play rounds in the experiment. In the third stage, after concluding participation in the rounds of the experiment, raise your hand so that the monitor may take a photocopy of your left and right hands.

Normally a second copy will be taken of your hands if the first copy is not clear, and you are requested to remove any rings or jewelry you may be wearing on your fingers. At the end of this phase, a winner will be drawn from among the volunteers for the prize accumulated during the experiment.

The experiment will last approximately 55 minutes. The instructions are simple, but must be followed carefully and, at the end of the experiment, you will receive a sum of money. The experiment is comprised of 13 consecutive rounds of a same lottery, but the first round will be a test and will not be worth anything, and thus you will only officially play 12 rounds. In each of the rounds, you will receive 100 m.u. (monetary units) and will decide how much of this amount you will bet on the following lottery:

- **You have two-thirds of a chance (67%) of losing the amount you bet, and one-third (33%) of winning 2.5 times the amount bet.**

In each round, the volunteer will key in the amount of the bet and confirm the amount, and will proceed accordingly in each subsequent round. Gains and losses will depend on the letter registered. This letter will be chosen by the volunteer at the beginning of the experiment from three options: A, B or C. The letter chosen by the volunteer shall be the same for all rounds of the experiment, i.e., all 12 rounds.

A volunteer will be the winner if his or her registered letter matches the letter randomly chosen by the program and will lose if his or her registered number is different. Each letter has a 1/3 (33%) chance of being drawn, and only after the amounts of the bets are placed will the letter be drawn by the program. Remember that since there are 3 letters, and that one of them will correspond to the letter chosen by you, your chance of winning will be 33% or 1/3, and of losing will be 67% or 2/3.

If a volunteer decides to bet X m.u. and wins, he or she will gain 2.5 times the amount bet plus the 100 u.m. received at the beginning of the round.

To illustrate a possible scenario, suppose a participant decides to bet 50 u.m. and wins. The total gain for the participant will be  $50 \text{ u.m.} \times 2.5 + 100$ , reaching at total 225 u.m., but in the case of a loss, the volunteer will remain with only the 50 u.m. not bet.

In the subsequent round, you will once again receive 100 u.m. and will decide how much of this amount you will bet on the lottery. The program will inform the gain for the round, and the amount accrued in all rounds.

Every two monetary units represents 1 centavo (2 u.m. is equal to 1 centavo) thus 100 u.m. represent fifty centavos of Real (R\$ 0.50).

Remember: your registry number will always be same, but a different letter may be drawn after each round. At the end of the experiment, your total gains will be added up and this will be

the amount that you may win after the last drawing of the experiment. Thus, randomly, by way of a drawing, 10% of participants will received the accumulated prize.

## 8.2 2. INSTRUÇÕES ESPECÍFICAS: HME-C

Thank you for participating in the choice under uncertainty experiment (decision-making). Please read carefully the instructions of the experiment.

Kindly do not communicate in any way with the other volunteers and, during the experiment, turn off you cell phone, iPad, or any other communication device.

Do not look at the choices made by the other participants so that you do not influence the choices made by the other participants and that theirs do not influence yours. If you have any doubts, raise your hand and the monitor will answer your question individually.

The experiment is comprised of three stages. In the first stage, you will respond to a questionnaire with questions on certain biological and social traits. In the second stage, you will play rounds in the experiment. In the third stage, after concluding participation in the rounds of the experiment, raise your hand so that the monitor may take a photocopy of your left and right hands.

Normally a second copy will be taken of your hands if the first copy is not clear, and you are requested to remove any rings or jewelry you may be wearing on your fingers. At the end of this phase, a winner will be drawn from among the volunteers for the prize accumulated during the experiment.

The experiment will last approximately 55 minutes. The instructions are simple, but must be followed carefully and, at the end of the experiment, you will receive a sum of money.

The experiment is comprised of 13 consecutive rounds of a same lottery, but the first round will be a test and will not be worth anything, and thus you will only officially play 12 rounds. In each of the rounds, you will receive 100 m.u. (monetary units) and will decide how much of this amount you will bet on the following lottery:

- **You have two-thirds of a chance (67%) of losing the amount you bet, and one-third (33%) of winning 2.5 times the amount bet.**

In each round, the volunteer will key in the amount of the bet and confirm the amount, and will proceed accordingly in each subsequent round. Gains and losses will depend on the letter registered. This letter will be chosen by the volunteer at the beginning of the experiment from three options: A, B or C. The letter chosen by the volunteer shall be the same for all rounds of the experiment, i.e., all 12 rounds.

A volunteer will be the winner if his or her registered letter matches the letter randomly chosen by the program and will lose if his or her registered number is different.

Each letter has a  $1/3$  (33%) chance of being drawn, and only after the amounts of the bets are placed will the letter be drawn by the program. Remember that since there are 3 letters, and

that one of them will correspond to the letter chosen by you, your chance of winning will be 33% or 1/3, and of losing will be 67% or 2/3.

If a volunteer decides to bet X m.u. and wins, he or she will gain 2.5 times the amount bet plus the 100 u.m. received at the beginning of the round.

To illustrate a possible scenario, suppose a participant decides to bet 50 u.m. and wins. The total gain for the participant will be 50 u.m. x 2.5 +100, reaching at total 225 u.m., but in the case of a loss, the volunteer will remain with only the 50 u.m. not bet.

In the subsequent round, you will once again receive 100 u.m. and will decide how much of this amount you will bet on the lottery. The program will inform the gain for the round, and the amount accrued in all rounds.

Every two monetary units represents 1 centavo (2 u.m. is equal to 1 centavo) thus 100 u.m. represent fifty centavos of Real (R\$ 0.50).

Remember: your registry number will always be same, but a different letter may be drawn after each round. At the end of the experiment, your total gains will be added up and this will be the amount that you may win after the last drawing of the experiment. Thus, randomly, by way of a drawing, 10% of participants will received the accumulated prize.

### 8.3 BIOLOGICAL AND SOCIAL TRAIT QUESTIONNAIRE

1. Your full name:
2. Your age:
3. Your data of birth:
4. Your gender: ( ) Male ( ) Female:
5. Your ethnicity: ( ) White ( ) Black ( ) Mixed ( ) Yellow ( ) Indigenous:
6. Your place in your family's birth order:
7. Your height:
8. Your weight:
9. Left or right-handed:
10. What is current semester:
11. Your email address:

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