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Biological characteristics modulating investor overconfidence

Marcia L. Zindel
Department of Production Engineering, University of Brasilia

Emilio Menezes
Department of Production Engineering, Federal University of Santa Catarina

Raul Matsushita
Department of Statistics, University of Brasilia

Sergio Da Silva
Graduate Program in Economics, Federal University of Santa Catarina

Abstract

Applying a standard questionnaire (Lichtenstein and Fischhoff 1977) to a sample of 44 professional investors, we sought for explicit correlations between selected biological characteristics of the investors and the cognitive bias known as overconfidence. We found that both male and female investors showed overconfidence above the subjective probability of 0.7 and underconfidence below this threshold. But the sexes seemed to behave differently when they were totally uncertain of their answers. Experienced and inexperienced investors were overconfident whenever they were 70 percent (or above) confident of their answers. Despite that, experienced investors were relatively more calibrated. Of those who were highly uncertain of their answers, the inexperienced showed less confidence. Moreover, a logistic regression analysis showed that male subjects, fathers, right-handers, and subjects with a university degree and less than five years of experience in stock markets were more prone to the overconfidence effect.

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1. Introduction

Decision-making in investing is increasingly believed to be not only rational but also plagued by cognitive biases and mental shortcuts ("heuristics") (Kahneman and Riepe 1998; Tversky and Kahneman 1974). Investors prone to such cognitive biases and heuristics run more risks than perceived by them (De Long *et al.* 1990) and thus end up with portfolios poorly diversified (Odean 1998). No other problem in judgement in decision-making is more prevalent and more potentially catastrophic than overconfidence. Overconfident investors systematically overestimate the precision of their own knowledge and skills, and this implies that they are wrong most of the times when they are confident they are right (Fischhoff *et al.* 1977). Whenever investor confidence outweighs investor accuracy financial markets overtrade, under-react to information (Kim and Verrecchia 1991), and become more volatile (Benos 1998). Evidence of overconfidence is shown in carefully controlled experiments. In questionnaires, overconfidence can be detected whenever the proportion of accurate judgments made by subjects is surpassed by their expected subjective probability of being correct (Gigerenzer *et al.* 1991).

Here, we conjecture that investor overconfidence can be influenced by the investors' "biological" traits. We employ a standard questionnaire (Lichtenstein and Fischhoff 1977) to a sample of 44 professional investor subjects to detect overconfidence and also to seek for explicit correlation of the bias with a subject's gender, age, handedness, second-to-fourth digit ratio, waist-to-hip ratio, emotional state, parenthood, and religiousness. We also add to those the characteristics "marital status" and "investor experience." We find that some of these characteristics matter.

The rest of this article is organized as follows. Section 2 describes selected literature related to the biological traits considered here; Section 3 presents the methods employed and data; Section 4 shows the results; and Section 5 concludes the study.

2. Biological characteristics

Here, we present selected literature on the characteristics "gender," "age," "handedness," "second-to-fourth digit ratio," "waist-to-hip ratio," "emotional state," "parenthood," and "religiousness." "Investor experience" is also discussed.

Gender

This characteristic has been already considered in literature. Both sexes show overconfidence, but men are believed to be more overconfident than women (Barber and Odean 2001; Lundeberg *et al.* 1994; Bengtsson *et al.* 2005). This mainly refers to those tasks recognized as manly (Deaux and Emswiller 1974; Lenney 1977; Beyer and Bowder 1997). In particular, men tend to be more overconfident in financial matters (Prince 1993).

Age

This characteristic has also been considered previously. Age seems to be negatively correlated with overconfidence, that is, youngsters are more overconfident (Kovalchik *et al.* 2004; Grimes 2002; Dittrich *et al.* 2005).

Handedness

Nearly 10 to 13 percent of any population is left-handed. Genetics plays a role, but it is not the only factor behind left-handedness. Left-handed people occupy the extremes when it comes to health and ability. There are more left-handed people with IQs over 140 than right-handed people. Left-handedness has also been associated with talent in music and sports. This may partly be due to the fact that left-handers have an intrinsic neurological advantage over right-handers. However, left-handedness has also been linked to epilepsy, Down syndrome, autism, and mental retardation. Left-handed peoples' life spans are shorter than those of their right-handed counterparts by as much as 9 years, which in part may be due to the prevalence of right-handed tools in society: left-handers are more prone to accidents. Male subjects are three times more likely to be left-handed than female ones. Raymond *et al.* (1996) and references therein give a full account of left-handedness.

Second-to-fourth digit ratio

Second-to-fourth digit ratio is a marker for prenatal testosterone exposure. High-testosterone men can be tracked by a relatively long ring finger. Men tend to have lower values of 2D:4D (~0.98) than women (~1), that is, men have relatively shorter index fingers (2D) as compared to ring fingers (4D). Low digit ratios are associated with higher sperm numbers, good health, physical aggression, enhanced fairness considerations, greater number of sexual partners and greater number of children fathered, superior athletic and musical ability, and higher levels of courtship behavior in the presence of potential mates. In ultimatum game experiments, low-digit-ratio high-testosterone men tend to lose their drive for a good deal after viewing sexy pictures, a result also replicated for salivary testosterone. Voracek and Loibl (2009) provide a survey of the digit ratio literature.

Waist-to-hip ratio

The waist-to-hip ratio (WHR) is the smaller circumference of the waist above the belly button divided by the hip circumference at the widest part of the hip. The ratio is applied to both women and men. Particular values of WHR are related to good health and fertility: WHR = 0.7 for women and WHR = 0.9 for men (Marlowe *et al.* 2005; Zaadstra *et al.* 1993; Kissebah and Krakower 1994; Guo *et al.* 1994; Seidell *et al.* 2001). Some argue that the WHR ratio is a better predictor of the risk of cardiovascular diseases than the body mass index. Women with WHR = 0.7 are considered more attractive by men (Furnham *et al.* 1997).

Emotional state

Emotional state influences investors' financial decisions (Ackert *et al.* 2003); for instance, investors in a good mood are more risk-averse (Isen *et al.* 1988), and anxiety tends to make them prone to choose gambles with low-risk payoffs. Risk-averse behavior may be governed by immediate responses to fear, which occur in the amygdala. The brain is evolved to make emotional and rational decisions on the one hand and controlled and automatic decisions on the other (Camerer *et al.* 2005). Controlled and rational decisions can either cooperate or compete with automatic and emotional decisions. Cost-benefit analysis only makes sense for controlled and rational decisions, but rational decision-making depends on prior accurate emotional processing (Bechara and Damasio 2005). Emotion can be beneficial to decision-making when it is integral to a task, but it can also be disruptive when unrelated to the task.

Parenthood

The process of raising kids alters behavior as neural and hormonal interactions are involved in nurturing babies. Estrogen triggers an increase in oxytocin (a hormone-like substance that promotes bonding patterns) in the expectant mother, and this affects her brain to promote maternal behavior. Prolactin also promotes care-giving behavior and directs brain reorganization to favor maternal behavior. Live-in father's oxytocin levels also rise toward the end of his mate's pregnancy. Oxytocin may be related to confidence (Fehr *et al.* 2005). Vasopressin (known as the "monogamy hormone") also plays a role in the father by promoting brain reorganization toward paternal and family bonding behavior. Vasopressin can reinforce father's testosterone level to protect his mate and child, but tempers his aggression, making him less capricious. Father's prolactin levels also rise after cohabitation with the child. Elevated prolactin levels in both the nursing mother and involved father cause some reduction in their testosterone levels, even though they also raise the pleasure hormones known as opioids. Fathers usually have lower salivary testosterone levels than unmarried men and married non-fathers. Gray *et al.* (2002) and references therein throw more light on this.

Religiousness

It seems odd but religiousness is, in a sense, a "biological" trait. There is neurological and evolutionary basis for religious experience. As suggested by "neurotheology," there are particular hormonal and neural characteristics associated with believers in the existence of God (Ramachandran *et al.* 1997). Low serotonin levels are related to "self-transcendence" which is a personality trait covering religious behavior and attitudes. The serotonin system may back spiritual experiences and explain why people vary greatly in spiritual zeal. Spiritual zeal may also have a genetic basis. Moreover, religious behavior interferes with economic rationality and attitudes toward risk (Iannacone 1998).

Experience

Experienced decision-makers are more confident though not necessarily more accurate (Trumbo *et al.* 1962). On average, experienced decision-makers are also more accurate than the inexperienced (Wallsten and Budescu 1983). However, in financial decision-making the evidence is mixed. Some studies find that experienced investors are less prone to overconfidence (Locke and Mann 2005; Christoffersen and Sarkissian 2002), while some others find exactly the opposite (Heath and Tversky 1991; Frascara 1999; Griffin and Tversky 1992; Kirchler and Maciejovsky 2002; Glaser and Weber 2007).

3. Materials and methods

We collected data from a sample of 44 professional investors, 31 males and 13 females. The investors were participating in events sponsored by the Association for Professional Investors in Capital Markets (dubbed APIMEC), which took place in Florianopolis, Brazil along the year 2008. Table 1 shows the sorted information gathered on bio-characteristics. Most were classified as binary variables. "Age" was not. We assigned subjects to five age categories: below 29 (12 subjects), 29 to 39 (15 subjects), 40 to 50 (9 subjects), 51 to 60 (4 subjects), and above 60 (3 subjects).

As for the investors' marital status, 15 subjects were single whereas 29 were not. Also, 23 subjects had children whereas 21 were childless; 36 subjects had a university degree whereas 8 had none. In accordance with the stylized fact discussed in the previous section, 11 percent of the subjects were left-handed: 5 left-handers and 39 right-handers in the sample. Moreover, 13 percent of the subjects reported to be atheists: 6 atheists and 38 God-believers. Finally, 24 subjects had more than 5 years of experience, while 20 had less than 5 years. Investors with less than 5 years of experience were considered to be inexperienced.

The investors were asked to identify their current emotional state considering the emotions depicted in the affective circumplex (Russell 1980) (Figure 1). The circumplex model proposes that all affective states arise from two fundamental neurophysiological systems, one related to valence (a pleasure–displeasure continuum) and the other to arousal or alertness. Each emotion can be understood as varying degrees of both valence and arousal. The circumplex model is believed to complement data from developmental, neuroimaging, and behavioral genetics studies of affective disorders (Posner *et al.* 2005). The investors were also asked to identify their current emotional state considering a continuous affect scale (Figure 2) which ranges from "very anxious" and "moderately anxious" to "emotionless," "moderately excited," and "very excited."

To assess investor overconfidence we applied the questionnaire in Table 2 (Lichtenstein and Fischhoff 1977), which involves 10 two-alternative general knowledge questions. Subjects chose one answer and estimated a probability (between 0.5 and 1) that the answer was correct.

When the subjective probability of a judgment (the estimate of how probable the judgment is of being correct) does not match its objective probability, there is poor "calibration," that is, over- or underconfidence. The overconfidence effect occurs when the confidence judgments are larger than the relative frequencies of the correct answers (Gigerenzer *et al.* 1991).

Here, calibration C is defined as the variance of the observed proportions of correct c_t around the corresponding levels of confidence r_t:

$$C = \frac{1}{N}\sum_{t=1}^{T} n_t \left(r_t - c_t\right)^2 , \tag{1}$$

where N is the total number of responses; T is the total number of response categories used; and n_t the number of responses in confidence category t. Overconfidence O is calculated using

$$O = \frac{1}{N}\sum_{t=1}^{T} n_t (r_t - c_t) . \tag{2}$$

Overconfidence occurs if $O > 0$ and underconfidence arises if $O < 0$. Definition (2) can be simplified as it equals the difference between the mean confidence score x and the mean proportion correct c (accuracy):

$$O = x - c . \tag{3}$$

All data from the questionnaires were analyzed through a logistic regression. The logistic regression (or logit model) is used for prediction of the probability of occurrence of an event by fitting data to a logistic curve. Like many forms of regression analysis, it makes use of several predictor variables to analyze their effects on a dichotomic variable in terms of the probability of being in one out of two states. In the logit model, we defined $P_{k|\mathbf{x}}$ as the probability of one subject to answer the k^{th} question related to overconfidence given the vector of biological characteristics **x**, that is,

$$P_{k|\mathbf{x}} = P(Y_k = 1 \mid \mathbf{x}) = \frac{e^{\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k}}{1 + e^{\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k}}, \tag{4}$$

where Y_k is a random variable that takes on the value of 1 if there occurs influence on the degree of overconfidence or 0 otherwise; and β_i are parameters related to characteristic i.

4. Results

Data were distributed normally (Table 3). They were only slightly positively skewed (0.178) and there was no excess kurtosis (that is, the kurtosis equals 0.7, which is well below 3). Then we carried out a *t* test and could not reject the null hypothesis of absence of the overconfidence effect (*p*-value < 0.0002).

The investors as a whole presented overconfidence, despite the fact that only five percent of the judgments ended up correct (Table 4). Figure 3 shows the calibration curve and the identity line of perfect calibration. More than 20 percent of predictions were made with 100 percent confidence in the judgment; whereas more than 20 percent of predictions were made with 50 percent confidence in the judgment, that is, total uncertainty. Underconfidence occurred for judgments with confidence levels up to 65 percent, and overconfidence occurred for judgment above this threshold. This suggests that the more a subject expected to be right, the greater he (or she) was prone to the overconfidence effect.

Table 5 suggests that male subjects were more overconfident than female subjects. The sexes behaved differently whenever they were totally uncertain of their answers. Figure 4 shows that for judgments with total uncertainty (subjective confidence levels of 50 percent), female subjects showed more confidence than male subjects, though this may be nonsignificant. Whenever female subjects were totally uncertain about the correctness of an answer (50 percent confident), they were actually 45 percent right. In contrast, whenever male subjects were 50 percent confident they were right, they were actually 55 percent right. However, as total uncertainty abated slightly (60 percent confidence levels), female subjects became less confident. Whenever they were 60 percent confident they were right, they were actually 85 percent right. In contrast, whenever male subjects were 60 percent confident they were right, they were actually 65 percent right.

Figure 4 also shows that for higher subjective confidence levels (above 70 percent) both sexes showed the overconfidence effect. For total subjective confidence, the gender of one subject made no difference. However, the accuracy seemed to vary depending on the gender for subjective confidence levels above 70 percent.

Figure 5 shows that regardless of experience, the investor subjects were overconfident whenever they were 70 percent (or above) confident of their answers. Despite that, the experienced investors were more calibrated (Table 6). Of those who were highly uncertain of their answers (subjective confidence below 70 percent), the inexperienced showed less confidence.

Considering the logistic regression given by equation (4), we adjusted 13 different models (using the bio-characteristics in Table 1). The Akaike criterion allowed us to choose the following model (Table 7):

$$\text{logit} = \log \frac{P_{k|\mathbf{x}}}{1-P_{k|\mathbf{x}}} = 0.30(\text{gender}) + 0.20(\text{parenthood}) + 0.30(\text{university degree}) \\ +0.49(\text{handedness}) + 0.26(\text{experience}) \tag{5}$$

Equation (5) gives the estimated logit, that is, the log of the conditional probability $P_{k|\mathbf{x}} \Big/ \left(1-P_{k|\mathbf{x}}\right)$. Each coefficient in equation (5) is an estimate of the β_i in equation (4). The coefficient values represent the contribution of each characteristic to the rise in the conditional probability. Thus, equation (5) allows one to define a profile for the overconfident investor: man, father, right-hander, with a university degree and less than five years of experience in stock markets.

5. Conclusion

We applied a standard questionnaire to a sample of 44 professional investors in Florianopolis, Brazil, to seek not only for the presence of the overconfidence effect but also to investigate to what extent the effect is modulated by selected bio-characteristics of the investors.

We found that male subjects were more overconfident than female subjects. Both sexes showed overconfidence above the subjective confidence level of 70 percent and underconfidence below this threshold. The data also suggested that the sexes behaved differently when they were totally uncertain of their answers.

We also found that experienced and inexperienced investors were overconfident whenever they were 70 percent (or above) confident of their answers. Despite that, experienced investors were more calibrated. Of those who were highly uncertain about their answers, the inexperienced showed less confidence.

Finally, a logistic regression analysis showed that male subjects, fathers, right-handers, and subjects with a university degree and less than five years of experience in stock markets were more prone to the overconfidence effect in our sample.

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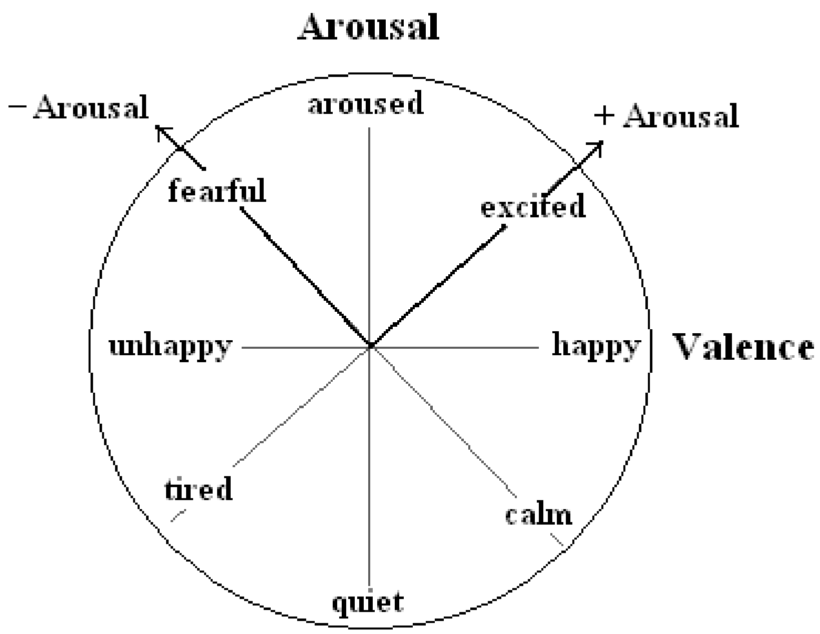

Figure 1. Affective circumplex: a graphical representation of the circumplex model of affect with the horizontal axis representing the valence dimension and the vertical axis representing the arousal or activation dimension

Very anxious	Moderately Anxious	Emotionless	Moderately Excited	Very excited

Figure 2. Emotional states described in a straight line

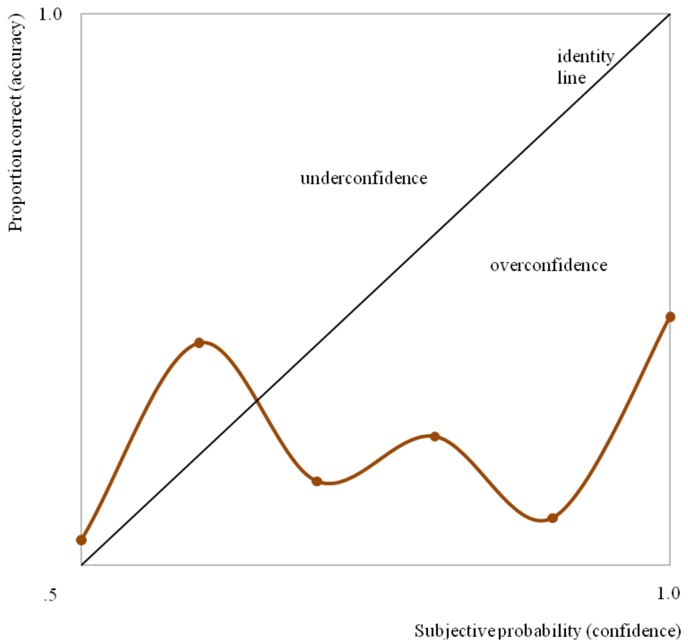

Figure 3. Calibration curve for the investor subjects as a whole

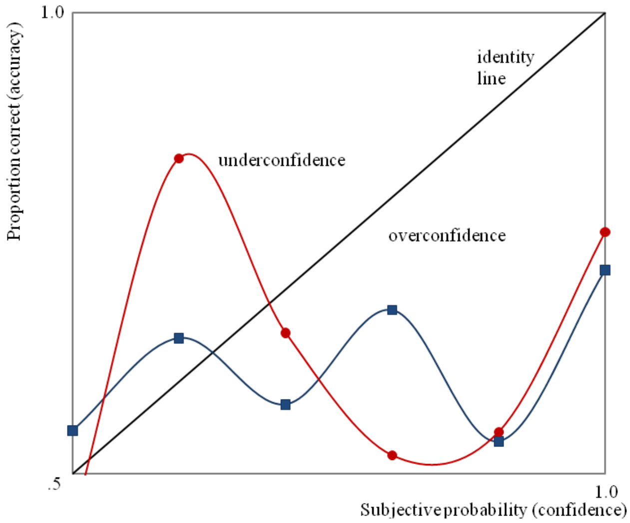

Figure 4. Calibration curve for males (blue font) and females (red font)

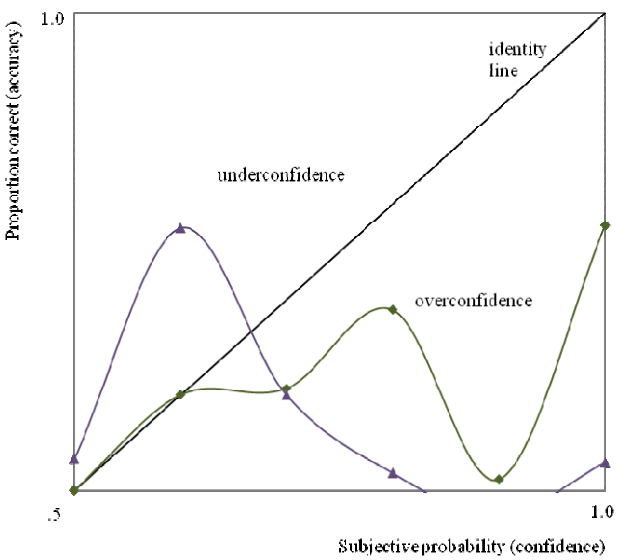

Figure 5. Calibration curve for experienced (green font) and inexperienced investors (purple font)

Table 1. Bio-characteristics

Variable	*Category*	*Value*
Gender	Male	1
	Female	0
Age	Not a binary variable	
Children	Yes	1
	No	0
Handedness	Right-hander	1
	Left-hander	0
Digit ratio	D2:D4 < 1	1
	Other	0
Waist-to-hip ratio	WHR < 1	1
	Other	0
Emotional state 1	Very anxious	1
	Other	0
Emotional state 2	Moderately anxious	1
	Other	0
Emotional state 3	Emotionless	1
	Other	0
Emotional state 4	Moderately excited	1
	Other	0
Emotional state 5	Very excited	1
	Other	0
Affective circumplex	Not a binary variable	
God-believer	Yes	1
	No	0
Experience	Less than 5 years	1
	Other	0
Marital status	Single	1
	Other	0
University degree	Yes	1
	No	0

Table 2. Questionnaire

1. The African continent consists of 53 countries. Yes/No
How confident are you that your answer is correct?
50% 60% 70% 80% 90% 100%

2. Portugal was the first European country to establish contact with India. Yes/No
How confident are you that your answer is correct?
50% 60% 70% 80% 90% 100%

3. When Marco Polo visited China this was dominated by the Japanese. Yes/No
How confident are you that your answer is correct?
50% 60% 70% 80% 90% 100%

4. The territory of Alaska was sold to the United States for Canadians. Yes/No
How confident are you that your answer is correct?
50% 60% 70% 80% 90% 100%

5. The air distance between London and New York is about 5562 km. Yes/No
How confident are you that your answer is correct?
50% 60% 70% 80% 90% 100%

6. The population of Spain is estimated at 40 million. Yes/No
How confident are you that your answer is correct?
50% 60% 70% 80% 90% 100%

7. Lebanon represents the current region where there were the Phoenicians. Yes/No
How confident are you that your answer is correct?
50% 60% 70% 80% 90% 100%

8. Italy has a territorial extension of 50,000 km^2. Yes/No
How confident are you that your answer is correct?
50% 60% 70% 80% 90% 100%

9. The Suez Canal was built by Spain. Yes/No
How confident are you that your answer is correct?
50% 60% 70% 80% 90% 100%

10. Auckland is the capital of New Zealand. Yes/No
How confident are you that your answer is correct?
50% 60% 70% 80% 90% 100%

Answers: 1.Yes, 2.Yes, 3.No, 4.No, 5.Yes, 6.Yes, 7.Yes, 8.No, 9.No, 10.No

Table 3. Normality tests

Test	*Statistic*	*p-value*
Kolmogorov-Smirnov	0.0711	*Pr* > statistic > 0.150
Cramer-Von Mises	0.0366	*Pr* > statistic > 0.250
Anderson-Darling	0.2847	*Pr* > statistic > 0.250

Table 4. Statistics for the subjects as a whole

Measurement	*Mean, %*	*Std Dev, %*
Calibration	5	7
Accuracy	46	8
Overconfidence	21	14
Overconfidence/Underconfidence	+11.43	18.81

Table 5. Statistics by gender

Measurement	*Mean, %*	*Std Dev, %*	*Measurement*	*Mean, %*	*Std Dev, %*
Female			*Male*		
Calibration	4.00	4.00	Calibration	5.00	8.00
Accuracy	13.27	6	Accuracy	32.80	7
Overconfidence	18	10	Overconfidence	22	16
Overconfidence/ Underconfidence	+12	16	Overconfidence/ Underconfidence	+11	20

Table 6. Statistics by experience

Measurement	*Mean, %*	*Std Dev, %*	*Measurement*	*Mean, %*	*Std Dev, %*
Experienced			*Inexperienced*		
Calibration	5.00	7.00	Calibration	4.00	8.00
Accuracy	80.85	11	Accuracy	66.90	9
Overconfidence	21	14	Overconfidence	18	10
Overconfidence/ Underconfidence	+12	20	Overconfidence/ Underconfidence	+10	18

Table 7. Statistics for the model chosen

Variable	*Degree of freedom*	*Parameter estimate*	*Std error*	*t-value*	*Pr* > |*t*|
Gender	1	0.29668	0.07837	3.79	0.0005
Parenthood	1	0.20274	0.09422	2.15	0.0377
University degree	1	0.29791	0.09326	3.19	0.0028
Handedness	1	0.49342	0.10100	4.89	< 0.0001
Experience	1	0.26263	0.08751	3.00	0.0047