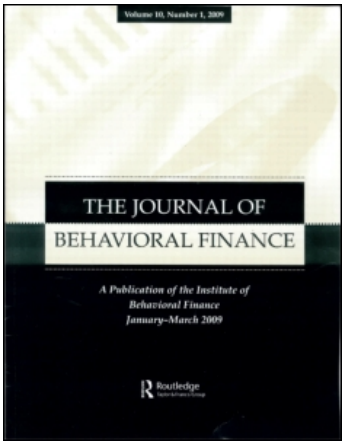

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Using an Eye Tracker to Examine Behavioral Biases in Investment Tasks: An Experimental Study

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Contrary to the premise of rational models, which suggests that investors' aggregate portfolios are the appropriate informational asset for evaluating a file performance, we find, using an eye tracker, that investors spend more time looking at performances of an individual asset than at the performances of the overall aggregated portfolio and at the net value change more than the assets' final value. We also find that investors look at the monetary value change longer than at change in percentages. Specifically, participants look longer at the value change of gaining assets than at the value change of losing assets. We propose the possibility that investors are not only engaged in judgment when evaluating their portfolio (leading to loss aversion and mental accounting) but may also be predisposed to looking for reassuring elements within it. Thus, it may be that humans use mental accounting by nature and not necessarily by judgment.

Keywords: Mental accounting, Loss aversion, Judgment, Eye tracker

1. INTRODUCTION

A growing literature in behavioral finance uses common behavioral theorems and biases, such as mental accounting (Thaler [1980, 1985]) and loss aversion (Kahneman and Tversky [1979]) to explain "anomalies" in the markets. This is often done by using laboratory experiments, surveys or empirical tests designed to examine hypotheses and understand the underlying mechanism behind these anomalies. The current study uses an eye tracker (see Appendix A for a photograph of the device) to provide deeper insights into investors' tendency to overweigh specific features of their portfolios. Eye trackers are commonly used to investigate how individuals deploy spatial attention (e.g., Hermans et al. [1999], Bradley et al. [2000], Mogg [2002], Wadlinger and Isaacowitz [2006]). We suggest that using an eye tracker to investigate financial decision making could shed light on the underlying mechanism that leads individuals to focus on specific elements in their portfolios, by monitoring investors' first reactions to different parameters (i.e., winning and losing assets) of their investment decision.

The basic rational portfolio theory suggests that final (i.e., aggregated) states are the ones that should matter for

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economic investments. Therefore, investors should evaluate their investment decisions based on the expected utility of their portfolios and not by specific portfolio components (Von Neumann and Morgenstern [1947], Savage [1954]). Moreover, investors should put more weight on the assets' final values and not on the change in the assets' values. However, based on previous research, the analysis of investors' behavior indicates that investors often pay less attention to assets' final values than to the changes relative to a reference point (Kahneman and Tversky [1979], Camerer [2000]). Furthermore, the literature on decision making suggests that investors are generally loss averse (Kahneman and Tversky [1984], Tversky and Kahneman [1991]), meaning that negative changes (losses) loom larger than equivalent positive changes (gains). In this sense, the effect (in absolute value) of a loss (as measured by utility) is higher than the effect of an equivalent gain (as measured by utility). In this study, we used an eye tracker to examine the underlying process behind mental accounting and loss aversion. Our main dependent variable was the time that participants spent looking at informational variables (e.g., loss, gain, value change, change in percentage, assets' final values) in an investment task.

Loss Aversion

A pending issue concerns which information attracts more of the investors' attention — positive information (i.e., winning assets) or negative information (losing assets). One possibility is that losing assets will attract more attention than winning assets (Shani and Zeelenberg [2007]), as losses loom larger than gains (Kahneman and Tversky [1979]). Mogg et al. [2000] have shown that negative stimuli often attract more attention than positive stimuli in highly anxious participants. Thus, individuals may spend more time looking at losing assets in order to experience the full-blown loss and put it behind them (Shani and Zeelenberg [2007]). While focusing on losing assets may be somewhat painful to the losing investor, important information related to the reasons that led to the loss are not ignored, which leads to better decision making in future investments (Roese [1994]). It follows that it may be better for decision makers to spend more time observing their losing assets than their positive assets.

Alternatively, individuals may pay more attention to winning assets in order to overcome the strong negative emotional state that follows losses. Some of the most famous behavioral biases are based on the idea that decision makers do their utmost to limit *exposure* to loss. Examples of these biases are expressed in the endowment effect (Thaler [1980]), myopic loss aversion (Benartzi and Thaler [1996]) and the disposition effect (Shefrin and Statman [1985]). More importantly, although looking at winning assets may feel good in the short run, in the long run important information might be ignored. Thus, this study is a direct test of whether investors express their aversion to negative information by looking at positive information (to compensate against their loss) or at negative information (to alleviate the unpleasantness of uncertainty) for a longer period of time.

Mental Accounting

Analyzing the ocular behavior of decision makers allows researchers to investigate a number of hypotheses based on the results of studies on decision-making processes. For instance, behavioral analysis indicates that investors tend to subdivide the investment problem into small decision units. Subdividing investments is explained by mental accounting principles introduced by Thaler ([1980, 1985]).[1] Odean [1998] suggests that investors evaluate each stock holding separately and are loss averse in each stock holding with respect to the purchase price. Rockenbach [2004] suggested that individuals cannot make a connection between different investment possibilities, and instead act as though they associate two risky assets (stock and options) in the same mental account while treating bonds in a separate one. We examine the existence of the mental accounting phenomenon by testing whether investors spend more time looking at the portfolio's components or the portfolio's final value. Based on mental accounting, it is expected that investors will look at the performance (net gain or loss) of each asset in a portfolio longer than at the portfolios' accumulated performance.

Percentage Change, Nominal Change and Final Value

Mental accounting principles are based on the assumption that decision makers use a set of heuristics to make their day-to-day financial decisions. For example, calculating percentage-off discounts are more complicated than calculating nominal discounts, since the former requires a multiplication process (Estelami [1999, 2003]). Having to calculate percentage-off discounts may leave buyers with lower confidence regarding their final calculated price (Deighton [1984], Pham and Muthukrishnan [2002]). The use of heuristics eases the decision-making process by making it simpler. Other economic phenomena suggest that people simplify the decision-making process by looking at the nominal values. For example, the "money illusion" (e.g., Shafir et al. [1997]) suggests that many people's preferences and perceptions of the constraints are affected by nominal values. Fehr and Tyran [2001] propose that the natural representation of an economic situation for most people is the nominal representation. Their explanation is based on the assumption that most economic transactions involve the use of money and are, therefore, framed in nominal terms. "Therefore, it is likely that people perceive and think about economic problems in nominal terms" (Fehr and Tyran [2001], p. 1241). Real responses that support this assumption are yet to be shown. Based on the above mentioned literature, it is expected that investors will look longer at the asset change (loss or gain) in nominal value (money change) than at the percentage change. This would provide direct evidence to

TABLE 1
The Investment's Results Screen.

Assets	Investment	Return in Percentage	Change in Value	Asset' Final value in Euro
A	X	$+100\alpha\%$	$+\alpha$ X	$(1+\alpha)$X
B	X	$-100\beta\%$	$-\beta$X	$(1-\beta)$X
Total	2X			$(2+\alpha-\beta)$X

the hypothesis that people perceive economic problems in nominal terms, supporting Kahneman and Tversky's [1979] findings that investors place less weight on the assets' final values and compare changes relative to an initial values (reference point). Based on the reference point, it is expected that investors will look longer at the assets' changes than at the assets' final values.

The use of a new measure for loss aversion and mental accounting, such as the one we suggest in this paper, is interesting and important because it discloses the type of information that attracts the majority of the investors' attention. In many sessions, investors should be open to having as much information as possible, to educating themselves and to making better decisions in the future. Simply put, our purpose is to learn what information attracts investors' attention when receiving feedback about their previous investment decisions.

The paper is organized as follows: Section 2 outlines the main hypotheses, section 3 presents the experimental method and section 4 presents the experimental results. Finally, section 5 summarizes and concludes.

2. HYPOTHESES

The hypotheses are based on the behavioral findings mentioned in the Introduction.

To illustrate the decision dilemma, assume that the decision maker invested in a simple portfolio containing two assets: A and B. In this particular investment example, asset A is a winning asset, and asset B is a losing asset. An equal amount of money was invested in each asset. The participant is looking at the following results from the investments:

The amount invested in each asset is X, the return (in percentage) is 100α for asset A and -100β for asset B. The changes, in nominal values, are αX for asset A, and $-\beta$X for asset B. The investor can also see the final value of each of his/her assets and the portfolio's final value. (See Table 1.)

The first hypothesis is based on loss aversion. Based on the idea that decision makers do their utmost to limit *exposure* to loss, we suggest that decision makers are trying to avoid losses and so they will tend to concentrate more on gains.

H1: Gains or losses: Investors will spend more time looking at the performance of gaining assets than at the performance of losing assets.

The second hypothesis deals with the nominal change and the change in percentage for each asset. As mentioned above, Fehr and Tyran [2001] argue that nominal representation of an economic situation is probably the natural representation for most people. Therefore, it is likely that people often perceive and think about economic problems in nominal terms. Based on this, we propose that:

H2: Nominal change versus change in percentage: Investors will spend more time looking at the change in nominal values than at the change in percentage.

The next hypothesis is based on one of the prospect theory principles mentioned above. As Kahneman and Tversky [1979] claim, investors place less weight on the assets' final values in comparison to the changes relative to initial values. Therefore, we expect the following:

H3: Change or final value: Investors will spend more time looking at the asset's change in value, relative to the initial value, than at the asset's final value.

The final hypothesis is based on one of the mental accounting principles. According to Thaler [1980, 1985], investors tend to subdivide the investment decision into small decision units. We expect to find the following:

H4: Portfolio or assets: Investors will spend more time looking at the value of each asset in their portfolio than at the value of their aggregated portfolio.

3. METHOD

Participants and Design

Twenty-seven students (15 females and 12 males, ages 22–26) at a major university voluntarily participated in this study for course credits. They were presented with an investment task in which four conditions (*High Gain* with *High Loss, High Gain* with *Low Loss, Low Gain* with *High Loss,* and *Low Gain* with *Low Loss*) within the subject design were presented randomly.

Apparatus

Eye movements were recorded using an infrared pupil refection system (Tobii X50 eye tracking system). This device made it possible to measure horizontal and vertical movements of both eyes simultaneously. The sampling rate was 50 Hz. The system has an absolute accuracy of 0.25″. Fixations were defined as eye recordings within 30 pixels for at least 100 msec. Thus, the total viewing time within specific areas of interest (AOI) can be calculated. The data derived from the eye tracker were recorded as percent gaze fixation

TABLE 2
Example for Investment's Results Screen.

Assets	Investment	Return in Percentage (R)	Change in Value (C)	Final value in Euro (V)
A	500 euro	$100\alpha\%$	500α	$500(1+\alpha)$
B	500 euro	$100\beta\%$	500β	$500(1+\beta)$
Portfolio	1000 euro			$500(2+\alpha+\beta)$

times instead of mean values in order to minimize the effects of momentary recording failures. Before the test, the device was calibrated using the software's 9-point monitor calibration, which was repeated until the system accepted the match.

Presentation of the stimuli and behavioral response collection were controlled using software specifically developed in a Labview 6 environment for the purposes of the present study.

Task and Procedure

The task included 12 trials randomly presented in order to avoid an order effect (three different sessions of trading days for each of the four investment conditions). Each trial was composed of three phases and involved the investment of 1000 Euros in two different assets. During the *first phase* of each trial, participants were told that they had previously invested 500 Euros on each of the two assets and a screenshot referring to this investment was shown.[2] In the *second phase*, the investments' returns were shown as follows. The presentation order of assets was counterbalanced. Some participants viewed asset A first and others viewed asset B first (see Table 2).

$\alpha$and β are the returns from assets A and B, respectively. Specifically, the three sets of returns from assets were presented in *percentages (Return in percentage, R)*, *change value in Euro (Change in Value, C)* and final value after the change *(Final value in euro, V)*. We did our best to make sure that the information on returns communicated in this study would be as similar as possible to the way in which this information is communicated to investors in real investments. All the cells in the above screenshot were defined as AOI, and eye fixation data were gathered for each of them. (See appendix B for the screenshots of actual screens used in the experiment.) Participants were instructed to treat trials independently of each other and were told that the gains and losses of the different 12 sessions would not be accumulated during the experiment.

We used four experimental conditions to test how individuals divide their attention between losing and winning assets. Participants were provided with information about four potential investment outcomes with different values (gain vs. loss) and dimensions (high vs. low). Thus, participants were presented with four different scenarios: high loss and gain, low loss and gain, high gain and low loss and low gain and high loss (Table 3).

TABLE 3
The Returns in Each Round.

Round	Condition	Gain	Loss
1	High gain-High loss	10%	–10%
2	High gain-High loss	11%	–11%
3	High gain-High loss	9%	–9%
4	High gain-Low loss	10%	–5%
5	High gain-Low loss	11%	–6%
6	High gain-Low loss	9%	–4%
7	Low gain-High loss	5%	–10%
8	Low gain-High loss	6%	–11%
9	Low gain-High loss	4%	–9%
10	Low gain-Low loss	5%	–5%
11	Low gain-Low loss	6%	–6%
12	Low gain-Low loss	4%	–4%

To enhance involvement in the task, in the *third phase* we asked participants to indicate how they would allocate their resources (another 1000 Euros) if they were to make a similar investment on the basis of the outcome from this investment.

The main reason for using this specific paradigm was to increase control in the experiment. Our main concern was that if we had given participants the opportunity to allocate money between the two assets, we would have gotten a different allocation to each asset for each subject, consequently limiting available statistical approaches to perform on this data. Thus, we were less interested in how allocations were divided, which has been vastly shown and discussed in the finance literature (such as mental accounting), and more interested in participants' responses (visual fixations) to loss and gain information.

Furthermore, it is possible that allowing participants to allocate different amounts themselves; consequently, enjoying (or suffering) different magnitudes of the loss and gain, affected the time spent focusing on either losing or gaining assets (hence, as suggested by the reviewer, standardization is unavoidable). For example, let us assume that subject 1 allocate 100 Euro in asset A and 900 Euro to assets B, and subject 2 allocate 900 Euro to asset A and 100 Euro to asset B. Assume that the return on asset A is $+10\%$ and on asset B, -5%. The time duration might have been confounded not only by the rates of loss or gain but also by the different amounts that were invested. Although both subject have the same negative return on asset B, subject 1 might have been more affected since he/she invested more in one asset rather than the other.

Table 3 presents the 12 scenarios. In some scenarios α was the winning return and β was the losing return; in other scenarios this was reversed.

Twelve trials (three different trials in each of the four experimental conditions) were randomly (to avoid any order effect)[3] presented with different return values.[4] The purpose

TABLE 4
Loss or Gain (Second Phase).

	Return in Percentage (R)			Change in Value (C)			Final Value in Euro (V)		
Condition	Gain	Loss	Z* (Sig)	Gain	Loss	Z* (Sig)	Gain	Loss	Z* (Sig)
High gain-Low loss	15.24% (15.58%)	11.89% (11.99%)	*1.227 (0.11)*	22.76% (18.74%)	18.72% (21.13%)	*1.337 (0.09)*	12.85% (12.84%)	12.33% (15.48%)	*0.778 (0.22)*
Low gain-High loss	15.2% (13.64%)	13.1% (12.63%)	*1.469 (0.07)*	22.73% (22.17%)	16.42% (16.52%)	*1.566 (0.06)*	13.77% (13.85%)	13.04% (11.23%)	*0.40 (0.34)*
Low gain-Low loss	14.34% (16.75%)	12.61% (12.31%)	*0.044 (0.48)*	24.54% (20.68%)	22.02% (21.42%)	*0.73 (0.23)*	12.74% (11.65%)	10.50% (11.33%)	*1.499 (0.07)*
High gain-High loss	14.12% (13.07%)	12.53% (12.91%)	*0.799 (0.21)*	24.27% (22.72%)	18.61% (22.53%)	*1.528 (0.06)*	14.66% (13.19%)	12.68% (12.57%)	*1.18 (0.12)*

+ Standard deviations in brackets.
*Wilcoxon signed ranks test to examine the hypothesis that the relative time spent on the losing asset and on the gaining asset is not different.

of doing three trials in each condition was to help us avoid an effect of specific numbers on the results. For example, if we take the returns +10% and – 10% (for high-gain and high-loss) we wanted to avoid the effect of the specific returns and so we also presented the other scenarios (+9% and -9% and +11% and –11%).[5]

Participants entered the lab individually and were seated in front of a computer monitor placed at a distance of 70 cm, with their heads on headrests. To prevent participants from inferring the hypotheses of the study, we first asked them to look at three images depicting visual illusions shown in sequence at the center of the computer monitor. Immediately following this, the investment game started. On average, participants needed about 20 minutes to complete the experiment.

4. RESULTS

In each phase, we measured the time participants spent looking at new information regarding their investments, meaning the cells belonging to the AOI. We excluded the time subjects spent blinking or observing elements that were irrelevant to the AOI (e.g., name of each asset, investment in each asset, keyboard, mouse). This is referred to as the "total duration." AOI in the second phase were the Return in Percentage (R), the Change in Value (C), the Final Value in Euro (V) and the final value of the portfolio. Overall, participants spent 57.4% of their time looking at the AOI (total duration) and 42.6% of their time looking at the name of each asset, the investment in each asset, the keyboard and other computer parts that were irrelevant to the investment (areas outside of the AOI).

We calculated the amount of time spent on each cell as a proportion of the total time spent on the AOI. To control for individual differences, we used the time *proportion* of each participant to measure his/her tendency to observe information within the investment parameters and then calculated the attention index. Thus, we were mainly interested in the time participants spent on each cell within the AOI under investigation. For each trial we calculated separately the relative time duration. Individual scores were averaged over repetitions (trading days) for each of the four investment conditions calculated to obtain the basis for analysis.

Table 4 displays the average, relative time proportion spent on the Return in Percentage (R), Change in Value (C), and Final Value in Euro (V) for the loss and gain assets.

Generally, for Returns in Percentage (R) and returns in Final Value in Euro (V) we cannot reject the null hypothesis because the time spent observing losing and gaining assets was the same. However, for Change in Value (C) we can reject the null hypothesis (for significance <10%) that the time spent on the losing assets equals the time spent on gaining assets. A different case would be the low gain and low loss condition, where we cannot reject the hypothesis that the time spent on C for loss and for gain is the same ($Z = 0.73$, $sig = 0.23$).

These results are partially consistent with hypothesis 1, which suggests that investors look at the performance of winning assets longer than at the performance of losing assets. The relative amount of time spent on the gaining assets is longer than the time spent on the losing assets only for Change in Value (C) and not for Change in Percentages (R) and Final Value (V), seemingly because the value change in Euro is perceived as more valuable information for investors, as suggested by Fehr and Tyran [2001]. This is also supported by the results shown in Table 5.

Table 5 presents the average of the relative time proportion spent on the Returns in Percentage (R) and on the Value Change in Euro (C) for each condition and separately for gain and loss.

Table 5 shows that for both gaining and losing assets, in all gain and loss conditions, we can reject the hypothesis that investors look at Returns in Percentage (R) and at Change in Value(C) for the same relative duration.[6] The participants spent more time looking at change in Value (C)

TABLE 5
Return Versus Change in Value for Losing and Gaining Assets.

	Gaining asset			Losing asset		
Condition	Return in Percentage (R)	Change in Value (C)	Z* (Sig)	Return in Percentage (R)	Change in Value (C)	Z* (Sig)
High gain – Low loss	15.24% (15.58%)	22.76% (18.74%)	*2.746 (0.003)*	11.89% (11.99%)	18.72% (21.13%)	*2.294 (0.01)*
Low gain – High loss	15.2% (13.64%)	22.73% (22.17%)	*1.713 (0.043)*	13.1% (12.63%)	16.42% (16.52%)	*1.342 (0.09)*
Low gain – Low loss	14.34% (16.75%)	24.54% (20.68%)	*3.467 (0.00)*	12.61% (12.31%)	22.02% (21.42%)	*2.785 (0.00)*
High gain – High loss	14.12% (13.07%)	24.27% (22.72%)	*2.826 (0.00)*	12.53% (12.91%)	18.61% (22.53%)	*1.278 (0.1)*

+ Standard deviations in brackets.
* Wilcoxon signed ranks test to examine the hypothesis that the relative time spent on return is not different from the relative time spent on the change in value.

than at Returns in Percentage (R). Once again these results are consistent with hypothesis 2 and previous findings by Fehr and Tyran [2001].

The results in Table 5 indeed indicate that the Change in Value (C) is more valuable information for investors than return in percentage. Participants spent more time looking at gaining assets than losing assets only when a change was communicated as nominal value (which seems to be a more significant informational factor), and not when the change was communicated as a percentage (R) or as the final value (V), as mentioned earlier.

Next, Table 6 presents the relative time spent looking at the nominal value change (C), and the assets' final value in Euro (V), gaining and losing separately. The results in Table 6 shows that we can reject the hypothesis that participants look at the Change Value in Euro (C) and at the Final Value in Euro (V) for the same relative duration.[7] The participants spend longer time looking at the Value Change (C) than at the Assets' Final Value (V). This is consistent with hypothesis 3. For the low gain-high loss condition in the loss domain, we cannot reject the hypothesis that the time spent looking at the Value Change (C) and at the Final Value (V) is the same ($Z = 0.635$, sig' $= 0.262$)**.**

To explain these results, we compared the relative time spent looking at the Value Change (C) of the losing assets in the low gain-high loss condition, and in the low gain-low loss condition. In both conditions the gain is the same (low) but the loss is different (high in the first condition and low in the second). The purpose of this comparison was to examine whether an increase in the loss (but not in the gain) reduces the time spent looking at the value change of the losing asset. Moreover, in a low-gain-high loss condition, the participant cannot use the gain to overcome the loss, since the gain is lower than the loss. In low gain-low loss, the participant may use the gain to overcome the loss since they are the same. We find that the relative time spent at Value Change (C) of the loss in low gain-high loss (16.42%) is significantly lower than the relative time spent at Value Change (C) of the loss in low gain-low loss (22.02%) ($Z = 2.38$, significance $= 0.009$). This indicates an attempt to avoid painful information when the loss becomes stronger, causing the participants to reduce the time spent looking at the value change of the losing asset; this is also reflected in participants spending the same amount of time on the Value Change (C) and the Final Value (V) of the losing asset in this scenario. When they were not able to find information that would compensate against the loss (that is, when the loss is relatively high and the gain is relatively low), they looked away.

Finally, Table 7 presents the time spent looking at the portfolio-final value and the gaining and losing assets' final values. We used the Wilcoxon signed ranks test to analyze the results. First, we compared the time participants looked at the final value of the portfolio (i.e., V-portfolio) with the final value of gaining assets (i.e., V-gaining asset). Then, we compared the time our participants spent looking at the final value of the portfolio (i.e., V-portfolio) with the final value of losing assets (i.e., V-losing asset). Table 7 shows that we can reject the hypothesis that participants look at the final value of the portfolio (i.e., V-portfolio) and at the final value of gaining assets (i.e., V-gaining asset) and losing assets (i.e., V-losing asset) for the same relative duration.

As expected in hypothesis 4, investors tend to subdivide the investment problem into small decision units and therefore tend to concentrate more on the final value of each asset (whether it was a losing or a gaining asset) in a portfolio than on to the portfolio's final value. These results are not consistent with the basic rational portfolio theory, which suggests that final states are the only ones that matter in investments and therefore investors should only care about the expected utility of their portfolios and not about the specific portfolio components (Von Neumann and Morgenstern [1947], Savage [1954]). As mentioned earlier, participants were asked to allocate another 1000 Euros between assets A and B for an additional round, based on the information on the assets' performance (R, C, V). Table 8 shows the average investment in each asset and in each condition.

Results show that investors tend to allocate higher amounts to gaining assets than to losing assets. This is consistent with the "recency" hypothesis, meaning that investors would base their decision on recent outcomes (see Barron and Erev [2003]) and allocate higher amounts to gaining assets (based on previously gaining assets).[8]

TABLE 6
Change in Value Versus Final Value.

	Gain			Loss		
Condition	Change in Value (C)	Final Value in Euro (V)	Z* (Sig)	Change in Value (C)	Final Value in Euro (V)	Z* (Sig)
High gain – Low loss	22.76% (18.74%)	12.85% (12.84%)	*3.370 (0.00)*	18.72% (21.13%)	12.33% (15.48%)	*2.260 (0.012)*
Low gain – High loss	22.73% (22.17%)	13.77% (13.85%)	*2.546 (0.005)*	16.42% (16.52%)	13.04% (11.23%)	*0.635 (0.262)*
Low gain – Low loss	24.54% (20.68%)	12.74% (11.65%)	*3.781 (0.000)*	22.02% (21.42%)	10.50% (11.33%)	*3.698 (0.000)*
High gain – High loss	24.27% (22.72%)	14.66% (13.19%)	*2.723 (0.003)*	18.61% (22.53%)	12.68% (12.57%)	*1.344 (0.09)*

+ Standard deviations in brackets.
* Wilcoxon signed ranks test to examine the hypothesis that the relative time spent on the value's change is not different from the relative time spent on the asset's final value.

For each subject and each trial we calculated the total time duration an investor looked only at the cells on the investment screen (without the time spent on the keyboard and parts of the screen not belonging to our AOI). For each cell on the screen we calculated the time proportion (from the total time duration spent on cells on the screen). In Table 9 we present the average relative time spent on the investment cells, for losing and gaining assets separately.

We cannot reject the hypothesis that the time spend on the amount allocated to the losing asset and to the gaining asset is not different. Although we find in the performance screen that that the time spent on the value change (C) for gain is higher than the time spent on the value change (C) for loss, we do not find any effect for loss or for gain in the investment screen. It is possible that since the investors do not see loss or gain in the investment screen, but only the names of the assets (A or B), the effect of loss aversion does not exist.

We were also interested in examining the link between visual patterns and actual behavior. Participants were asked to allocate another 1000 Euros between assets A and B for an additional round, based on the information on the assets' performance. Table 10 presents the correlation between the allocation to the gaining assets and the relative time spent on the value change in Euro (C)[9] of the losing assets and the gaining assets.

The table shows that only in the high gain-low loss scenario did the time spent on the losing and on the gaining

TABLE 8
Investment in Each Asset and Each Condition.

	Investment		
Condition	Gain Asset	Loss Asset	Z* (Sig)
High gain – Low loss	667.4 (200.4)	332.6 (200.4)	*7.037 (0.00)*
Low gain – High loss	692.9 (170.7)	307.1 (170.7)	*7.086 (0.00)*
Low gain – Low loss	663.4 (158.5)	336.6 (158.5)	*6.979 (0.00)*
High gain – High loss	678.0 (164.6)	322.0 (164.6)	*6.117 (0.00)*

+ Standard deviations in brackets.
* Wilcoxon signed ranks test to examine the hypothesis that the money allocated to the gaining asset is not different from the money allocated to the losing asset.

TABLE 9
Relative Time Spent on the Investment Cells in Each Condition.

	Investment		
Condition	Gain Asset	Loss Asset	Z* (Sig)
High gain – Low loss	45.15% (35.33%)	46.22% (34.91%)	*0.148 (0.44)*
Low gain – High loss	44.41% (34.79%)	47.09% (34.58%)	*0.342 (0.37)*
Low gain – Low loss	45.73% (36.95%)	43.79% (36.63%)	*0.347 (0.36)*
High gain – High loss	41.37% (34.20%)	47.15% (36.90%)	*0.40 (0.21)*

+ Standard deviations in brackets.
* Wilcoxon signed ranks test to examine the hypothesis that the relative time spent on the investment in the losing asset is not different from the relative time spent on the investment in the gaining asset.

TABLE 7
Looking at the Portfolio's Final Value.

	Portfolio – Final value in Euro (V-portfolio)	Gaining asset final value (V-gaining asset)		Losing asset final value (V- losing asset)	
Condition	Relative time	Relative time	Z* (Sig)	Relative time	Z* (Sig)
High gain – Low loss	6.22% (8.21%)	12.85% (12.84%)	4.254 (0.00)	12.33% (15.48%)	3.499 (0.00)
Low gain – High loss	5.74% (9.37%)	13.77% (13.85%)	4.737 (0.00)	13.04% (11.23%)	4.350 (0.00)
Low gain – Low loss	3.26% (4.69%)	12.74% (11.65%)	5.564 (0.00)	10.50% (11.33%)	4.996 (0.00)
High gain – High loss	3.13% (5.31%)	14.66% (13.19%)	6.066 (0.00)	12.68% (12.57%)	5.646 (0.00)

+ Standard deviations in brackets.
* Wilcoxon signed ranks test to examine the hypothesis that the relative time spent looking at the portfolio final value is not different from the relative time spent looking at each asset final value.

TABLE 10
Correlation between the Allocation to the Gaining Assets and the Relative Time Spent at the Change Value in Euro (C) of the Losing Assets and the Gaining Assets. (correlations and sig' in brackets)

Allocation to gaining assets in the condition	Relative time on gaining assets value change	Relative time on losing assets value change
High gain – Low loss	0.34 (0.00)	–0.31 (0.01)
Low gain – High loss	0.04 (0.74)	0.13 (0.25)
Low gain – Low loss	–0.17 (0.13)	–0.02 (0.86)
High gain – High loss	0.00 (0.97)	–0.13 (0.26)

assets value change affects the investment allocation. In the high gain-low loss scenario the gain was high enough to reduce the strong effect of the loss. In all other scenarios, the loss equals the gain or is higher than the gain and, as a result, has a stronger effect. Specifically, when the loss equals the gain, the loss has a stronger effect due to loss aversion. The findings in Table 10 show that when the gain has an effect the time spent on the value change does affect the allocation rate to each asset. More time spent on the gaining asset increases the allocation to this asset. More time spent on the losing asset reduces the allocation to the gaining asset.

5. SUMMARY AND CONCLUSIONS

This paper is the first to use time duration measures obtained by tracking eye motion to monitor investors' behavior. Although there is a growing number of experimental and theoretical works that explain investors' behavior, to the best of our knowledge none have used basic techniques such as eye tracking measurements to establish the underlying process. Eye trackers are used mostly in marketing, cognitive psychology or medical research laboratories but not in finance or economic research. We hope that this research will inspire further investigation in finance, economics and managements to use this and similar techniques to better understand investors' behavior. Specifically, from the current research, we learn that not only do investors focus on specific elements within the portfolio (which is already well established), but they attribute different values to different features within the portfolio, features that may influence future decisions.

When investing in capital markets, investors' portfolios often include information about winning and losing assets. In order to maintain an aggregated profitable portfolio, a "rational investor" should spend more time assessing the performances of the whole portfolio and less time on the impact of specific components. This is the main premise of the literature on decision making and the mental accounting phenomenon, which has shown that investors often give too much weight to the performances of specific assets within a portfolio and not enough to the portfolio's overall performance (Thaler [1980, 1985], Odean [1998], Rockenbach [2004]). Our results provide physical evidence of the mental accounting phenomenon by showing that participants also spend more time *looking* at the final value of each asset than on a portfolio's final value.

Furthermore, the reference point phenomenon suggests that investors put too much emphasis on a change in value and to little on the assets' final value (Kahneman and Tversky [1979], Camerer [2000]). Our results also provide physical evidence for the reference point phenomenon by showing that participants spent a longer time *looking* at the asset's Change in Value (C) than at the asset's Final Value (V).

Another interesting finding is that investors looked for a longer duration at the value change than at a percentage change. This is consistent with our hypothesis that percentage change is harder to calculate than the nominal change because it requires multiplication, and therefore people prefer the nominal change. These are important insights because in real life, when comparing portfolio's assets, the percentage change serves as valuable information because it is the accurate strategy for comparing assets' real value, while nominal change might mislead the investors.

The research results are partially consistent with the loss aversion phenomenon (and shed more light on its underlying mechanism), and provided physical evidence of loss aversion only when a change was communicated in nominal value rather in change in percentages. More importantly, these results add to the existing theory by suggesting that loss aversion may be most salient when information (related to investments) communicated to the investor is indeed perceived as more valuable by the investor.

There are empirical observations that many individual investors hold fewer individual stocks than necessary in order to eliminate idiosyncratic risk (e.g., Statman [1987, 2004], Kelly [1995], Odean [1999], Polkovnichenko [2005]). This behavior has been discussed and explained extensively in the behavioral literature, where it is interpreted by classic loss aversion and mental accounting biases. Our research takes us one step further by suggesting that these biases may be considered as part of a fundamental human tendency to focus on specific features within an investment in general, and more specifically, as a basic need to look for reassuring information within the investment data. Simply put, it is possible that investors are not only engaged in *judgment* when evaluating their portfolios (leading to loss aversion and mental accounting) but also may be predisposed to look for reassuring elements within it. It may be that humans use mental accounting by nature and not necessarily by judgment. This may explain why professionals, although perfectly aware of these biases, often fall victim to the misconceptions of mental accounting and loss aversion. Financial institutions, such as banks and mutual funds that wish to encourage their clients to diversify their investments, should take these findings into consideration when presenting their clients with their portfolio performances. Specifically, financial

institutions may want to first emphasize the portfolio's final value to investors, and only then provide them with the opportunity to further explore the portfolio's components. This will require investors to observe the portfolio final values before they are influenced by specific features. This, however, is a matter for a future researcher who wishes to provide solutions to the under-diversification of investors.

NOTES

1. There are other "anomalies" in behavioral finance which can be explained by using the mental accounting principles (see DeBondt and Thaler [1995], Shiller [1998], Thaler [1999]).
2. The experimental situation follows real life situations, such as where investment fund managers decide on the investment amounts of each asset individually. Specifically, in this study we wanted to test and learn what would be the most important piece of information (e.g., positive or negative, change in value or in percentage) for investors, having to base one investment decision on a previous one.
3. We did not analyze the influence of the order of presenting the gain or the loss, since in this paper we tried to focus on the importance of each information variable on the investors' decision making. (Any analysis of the order effect of the treatment or the losing/gaining asset would have moved this paper from its main focus.)
4. The recording of eye movement is quite complex. To prevent technical noise in the data we asked each participant to be involved in three trading days for each condition. The returns in each trading day were different.
5. Averaging across repetitions has to do with the notion of measurement in the mathematical theory of measure, since there is always a random error component which can be of different size and is unknown. This makes relying on a single observation (measure) problematic from a methodological point of view.
6. For all the cases, the significance is lower than 0.05 except, in the losing asset, for low gain-high loss where: $Z = 1.342$, sig $= 0.09$ and for high gain-high loss: $Z = 1.278$, sig $= 0.1$.
7. The only case that is not significant is low-gain-high loss ($Z = 0.635$, sig' $= 0.262$). For high gain-high loss the significance is lower than 10% but higher than 5% ($Z = 1.344$, sig' $= 0.09$).
8. In the third phase, subjects invested more based on their "earnings" in the second phase, leading to higher gains. This indicates that subjects were tuned, involved and aware of the game's rules and constraints. If not involved they would have not had any reason to invest as they did, trying to boost performance.
9. We took the change in value since it is the most important variable, as shown in Tables 5 and 6.

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APPENDIX A: EYE-TRACKER

This is an image of the eye tracker (Tobii X-50) we used for the experiment:

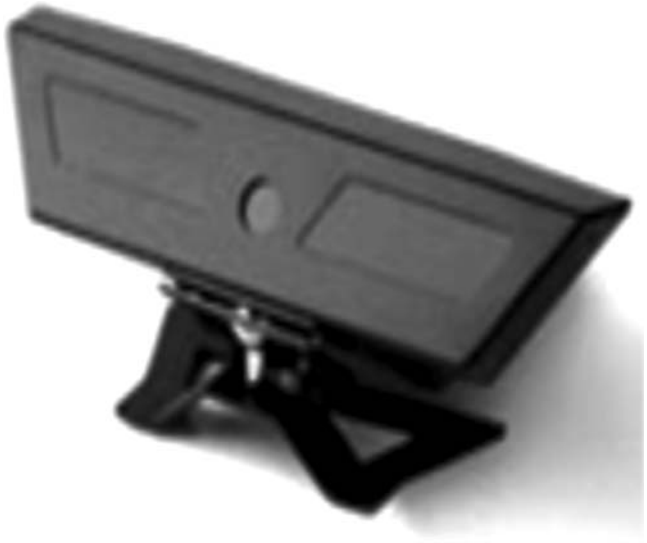

FIGURE A1

APPENDIX B: THE ORIGINAL SCREENS

First Screen

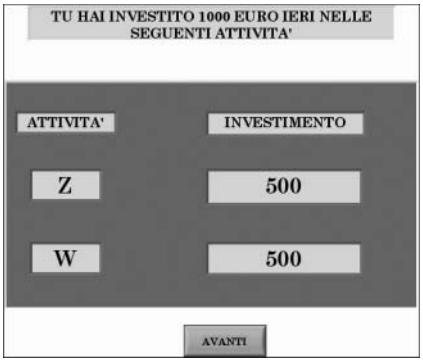

FIGURE A2 English translation of the Italian words on this screen: You invested 1000 Euro yesterday in the following assets: Assets Investment Push the button to continue.

Second Screen

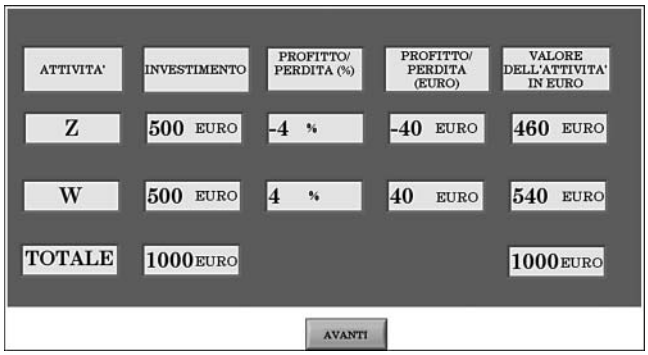

FIGURE A3 English translation of the Italian words on this screen: You invested 1000 Euro yesterday in the following assets: Assets Investment Push the button to continue.