Emotional responses to financial information

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Abstract

A longstanding controversy in accounting and finance is whether financial markets are governed by rational forces or by emotional responses. The dominant view is that investors are rational and markets efficient and that, on average, there is no room for emotions. Despite the efforts of behavioural finance which challenges those assumptions, prior research based on archival or self-reported data has not opened the "black box" of the potential role of emotions in investors' beliefs revision, a crucial intermediate between information and prices. To overcome this hurdle, we study the role of emotions as a complement to rationality in the decision-making process of traders by measuring their electrodermal response, a proxy for emotional response, during an experiment modeled on a simple but representative investment decision. This multi-trial within-subject experiment exposes each subject-trader to the announcement of earnings and to the revelation of the gain or loss on his investment decision. While controlling for other variables likely to affect a trader's emotions, we find a statistically significant change in the emotional response of subject-traders when they are informed of their gains or losses. Furthermore, in line with Prospect theory, losses trigger a higher emotional response than gains. We also find that emotions moderate the "rational" relationship between unexpected earnings and excess stock returns. Our findings support behavioural finance view that investors are not fully rational and that emotions affect their belief revisions following new financial information.

1. Introduction

The ups and downs in the stock market since the beginning of the century have intensified the debate as to whether financial markets are governed by rational forces or by emotional responses (Shiller 2003; Lo and Repin 2002). As first pointed out by Beaver 1968, market price variations reflect the average change in traders' expectations or beliefs due to the announcement of new information. On the one hand, traditional finance (TF) assumes that investors have rational expectations and markets are efficient, i.e., prices fully reflect all available information (Samuelson 1965; Fama 1970). On the other hand, following the seminal work of Shiller 1981, behavioral finance[1] (BF) has been developed on the view that investors make systematic errors, leading to irrational reactions to information. BF investigates cognitive and emotional factors affecting financial decision making processes of individuals, groups, and organizations (Howard 2012). A prominent example of BF is Prospect theory (Kahneman and Tversky 1979) which replaces the traditional efficient markets hypothesis and expected-utility representation with factors suggested in psychology. In both TF and BF, traders' belief revisions are a crucial intermediate between information and prices (Chen, Cheng, and Lo 2013), but are difficult to observe in real time. Both streams of research using archival or self-reported evidence failed to open the "black box" of the role of emotions behind investors' beliefs revisions following new financial information.

Therefore, the objective of this paper is twofold: First, we revisit this fundamental research question in an experimental setting where a physiological measure is used to determine whether emotions play a role in traders' belief revisions following the announcement of new financial information and whether the emotional response differs when the information

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[1] Fama and Shiller, the proponents of these two opposing views, are co-recipient of the 2013 Nobel Prize in economics which is an indication of a continuing debate.

involves a loss for the trader. Second, we examine whether changes in traders' emotions affects the "rational" relationship between earnings announcement and excess stock returns.

Of all financial accounting information regularly reported by publicly traded firms, earnings, especially earnings per share (EPS), are key metrics for investors (Gibbins, Richardson and Waterhouse 1990; Graham, Harvey, and Rajgopal 2005). Further, Basu, Duong, Markov, and Tan 2013 infer that earnings announcements are a superior information source in the competitive corporate information market. Meeting or beating analysts' forecast of earnings is a notion well entrenched in today's corporate culture (Bartov, Givoly, and Hayn 2002), while missing EPS target (even slightly) is interpreted as evidence of hidden problems at the firm (Graham et al. 2005). If stock market reaction to good or bad earnings surprise is well documented in the literature (Kothari 2001 and Bamber, Barron, and Stevens 2011), we do not yet fully understand the emotional response behind traders' belief revisions. In this study, we use skin conductance response (SCR) to observe the emotions underlying traders' belief revisions. In psychophysiology, SCR is regularly used to measure emotional arousal and to address how we attribute value to the choices we make (Naqvi and Bechara 2006).

So, this study builds on empirical and behavioural research in accounting and finance to contribute to the newly emerging discipline of neuroaccounting (Birnberg and Ganguly 2012). Previous research on earnings announcements was mostly based on in-depth field interviews and surveys such as in Gibbins et al. 1990 or Graham et al. 2005 or on archival data such as the research reviewed in Bamber et al. 2011 and Kothari 2001. Instead, we use psychophysiological instruments and theory to better observe and measure whether investors emotionally respond to earnings information to take their decisions. We believe that merging insights from multiple disciplines and research methods has the potential to yield valuable new knowledge.

Our multi-trial within subject experiment is modeled on a simple but representative financial decision making process where a subject-trader first forecasts a firm's current EPS, based on historical EPS and financial analysts' consensus forecasts. He then takes either a long or short position in that firm's stock. The emotional response of the participant is then measured twice: first, when the actual EPS reported by the firm in an earnings press release is announced to the participant. Second, when the participant is informed of the contemporaneous change in the firm's stock price and of the resulting gain or loss from his investment decision.

We hypothesize and find that, after earnings announcement, investors emotionally respond when they are informed of their gains or losses which convey information akin to rewards and punishment (Carver and White 1994; Bartov et al. 2002). The experiment also tests and corroborates Prospect theory (Kahneman and Tversky 1979; Tversky and Kahneman 1992). Indeed, we find that a loss is likely to lead to a stronger emotional response than a gain. We control for other variables likely to affect the emotional response of investors such as their risk tolerance, gender, and professional experience. Finally, we find that emotions moderate the rational relationship between earnings surprise and excess stock returns.

The evidence from this study is relevant for managers, regulators, and academics. From the perspective of managers, meeting or beating analysts' forecasts almost appears to be part of their job description perhaps because they believe earnings announcements can change traders' beliefs. This study broadens the theoretical foundations for explaining investors' reaction to earnings announcements, thus providing managers with a better basis for understanding how investors react to accounting disclosures. For regulators responsible for the quality of the financial reporting system, the evidence from this study suggests that investors' emotions play a significant part in their reaction. This departure from the efficient market hypothesis (Fama 1970, 1991) could have implications for future regulation of similar types of disclosures.

Finally, this study also has implications for behavioural accounting and finance research that examines stock price reactions to information by taking into account psychological biases such as in Daniel, Hirshleifer, and Subrahmanyam 1998. In these streams of research, traders' emotions represent a potential omitted variable. This study provides theoretical explanations and empirical evidence on how emotions are influenced by earnings announcements and influence investors' reactions to earnings news.

The rest of this article proceeds as follows. Section 2 presents the background of our study and the development of our hypotheses based on behavioural accounting and finance and on psychophysiology. Follows a brief exposure as to how we use technologies issued from neuroscience to explore a fundamental issue in finance and accounting research. Section 3 then describes our experimental research design. Section 4 presents our analyses and results, and Section 5 our conclusions.

2. Hypothesis development

The goal of this study is to examine whether emotions play a role in the decision-making process of traders, when they revise their beliefs or rational expectations[2] following new information. The efficient market hypothesis (EMH) in its semi-strong form largely ignores the influence of emotions on financial decision making (Bechara and Damasio 2005). This implies that stock prices adjust instantaneously and in an unbiased manner to all publicly available new information. Thus, the theory holds that investors cannot earn excess returns by trading on that information without bearing risk. However, the finance literature provides evidence of anomalies with regards to the EMH.

For instance, in the case of earnings announcements, Bernard and Thomas 1989 (1) underline that, starting with Ball and Brown 1968 (173), several studies have shown that

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[2] Expected utility theory assumes that investors are rational economic actors that select alternative options with the highest expected utility or value (von Neumann and Morgenstern 1944).

"even after earnings are announced, estimated cumulative abnormal returns continue to drift up for "good news" firms and down for "bad news" firms". This reaction to the earnings announcement goes against the EMH according to which the information content should be quickly integrated in investors' rational beliefs and impounded in efficient market prices. Other studies (De Bondt and Thaler 1985, 1987) have put forward an overreaction effect to dramatic and unexpected events.

Behavioral finance has emerged in response to the mounting evidence of departures from the fundamental hypotheses of market efficiency and has developed models of human psychology as it relates to financial markets (Shiller 2003). In BF, the challenge remains to explain how investors form and revise their beliefs or expectations. The BF line of research builds on the anomalies often revealed in EMH studies to argue that investors are often irrational. For BF (Chen et al. 2013) and neuroeconomic research on decision making (Bechara and Damasio 2005), belief revisions do not occur almost mechanically through the Bayes rule (Grossman 1976). To study the relation between new information, trading activities and price changes, we need to dissect the belief revision process. The study of Chen et al. 2013 is the first to attempt to explicitly examine the belief revision assumption. They measure revelations of analyst belief revisions in real time by using transcripts of their questions and comments in earnings conference calls with management. Their main result is that prices adjust to the direction and strength of the analyst (emotional) tone in the days following the conference call.

Evidence from psychophysiology (Bechara and Damasio 2005; Damasio 1994) shows that the involvement of emotions is not only crucial for accurate decision making but that advantageous (economic) decision making is not possible without emotions (Bechara et al. 1997). Damasio 1994 (71) defines emotions as the "collection of changes in body and brain states which are triggered by a dedicated brain system that responds to specific contents of

one's perceptions, actual or recalled, relative to a particular object or event". So, human emotions serve the function of unconsciously focusing and prioritizing one's attention on significant events such as in the announcement of new information.

Emotional response behind investors belief revisions

To examine whether emotions play a role in traders' belief revisions following the arrival of new financial information, we use two moments in the trading decision: when the earnings are announced (i.e., earnings surprise) and when the trader is informed of the gain or loss on his investment decision (i.e., excess stock returns). The earnings surprise, or the difference between the actual EPS and the prior EPS analyst consensus, is known to affect the magnitude of the stock market reaction since the seminal works of Beaver 1968 and Ball and Brown 1968. Since then, a large body of literature reviewed in Kothari 2001 and Bamber et al. 2011 generally confirms that investors react to earnings announcements and that both stock market reaction and trading volume are related to the absolute earnings surprise.

According to Graham et al. 2005, management executives believe that hitting earnings benchmarks builds credibility with the market and helps to maintain or increase their firm's stock price. On the opposite, missing EPS target (even slightly) is interpreted as evidence of hidden problems at the firm or the firm is perceived as poorly managed as it cannot accurately predict its own future. Bartov et al. 2002 find that firms that meet or beat current analysts' earnings expectations enjoy a higher return over the quarter than firms with similar quarterly earnings forecast errors that fail to meet these expectations. Using a combination of in-depth field interviews and a questionnaire to survey more than 400 executives, Graham et al. 2005 identify earnings for the same period of the last year and corresponding analyst consensus as the two most important earnings benchmarks. If earnings have informational content, exceeding or missing earnings benchmarks and their consequences on investors' wealth are bound to arouse investors' emotions. Based on finance (Bartov et al. 2002) and

psychophysiological theory (Carver and White 1994), we argue that earnings, gains or losses announcements convey information to investors akin to rewards and punishment.

The Reinforcement learning theory (RLT) proposes an explanation for how learning agents process information in order to achieve their goals and maximize their rewards (Montague, Dayan, and Sejnowski 1996; Schultz, Dayan, and Montague 1997, and Niv 2009). According to RLT, as learning agents, traders not only use what they already know, but also unconsciously take into consideration their past earnings prediction errors to figure out how to reduce them to get better results in the future. Facing a buy or sell decision, on the one hand, traders rationally trade based on the information they have such as actual past earnings and earnings forecast. On the other hand, according to RLT, they also emotionally or cognitively process past prediction errors in order to maximize their rewards and avoid punishments. This leads to our first hypothesis (H1) of a positive relation between earnings surprise and traders' emotional response following earnings announcement.

HYPOTHESIS 1. *Traders' emotional response is positively related to the earnings surprise.*

Despite the above, there are also many valid reasons for adopting the position that we should not expect accounting earnings announcements to surprise or provide substantial new information to the capital market. Three reasons are frequently offered for the lack of informational value of earnings. First, measurement errors in earnings are so important that it would be better to estimate stock value directly from the instrumental variables rather than use earnings as an intermediate step (Beaver 1968). Second, there is a myriad of sources of more timely information available to investors, such as industry, and other firm-specific information. Third, Ball and Shivakumar 2008 blame the lack of information value of earnings announcements on their relative frequency. Compared to other corporate news, earnings announcements are statutory, backward-looking, and only occurring quarterly. On

the other hand, revisions in expectations following other discretionary information occur relatively continuously and are also impounded in market prices.

So, the presumed informational value of accounting earnings is not unanimous in the accounting and finance literature and our subject investors are aware of this. If earnings announcements have poor or no information content, they will not lead to a change in investors' expectations and will not affect their emotional response. To circumvent the possible non relevance of earnings information, we develop a second hypothesis to examine investors' emotional response when they are informed of their investment performance. We suggest that there is a positive relationship between a trader's emotional response when he is informed of the contemporaneous change in the firm's excess stock return and the resulting gain or loss from his trading decision.

HYPOTHESIS 2. *Traders' emotional response is positively related to excess stock returns.*

Next, we test Prospect theory (Kahneman and Tversky 1979; Tversky and Kahneman 1992) by investigating whether traders' emotional response is the same when a gain or a loss is realized. This theory puts into question the standard information theory of expected utility where investors are rational and markets are efficient. Prospect theory suggests that people do not react to gains and losses with the same emotional intensity. They are more sensitive to loss (punishment) than to gain (reward). In other words, the pain caused by a loss is more intense than the joy caused by a similar gain. The psychophysiological literature designates this phenomenon as the "negativity bias" where the human brain is more sensitive to unpleasant news or memories as compared to positive ones. From their review of several studies of everyday phenomena, such as the learning process, Baumeister, Bratslavsky, Finkenauer, and Vohs 2001 (323) conclude that "bad emotions, bad parents and bad feedback have more impact than good ones, and bad information is processed more thoroughly than good". This leads to our next hypothesis:

HYPOTHESIS 3. *Traders' emotional response is stronger in the case of a loss compared to a gain.*

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The relative influence of emotions and earnings surprise on stock returns

Because stock returns capture investor belief revisions, if their emotional response is essentially a psychophysiological measure of the earnings surprise, we also expect it to be associated with stock returns around the announcement period. This is consistent with the literature in financial accounting (Kothari 2001) showing a positive association between stock returns and earnings surprise. With this in hand, to investigate if, contrary to the predicaments of the EMH (Bechara and Damasio 2005; Shiller 2003), emotions play a role in investors belief revisions, our second hypothesis examines whether traders' emotional response moderates the relationship between earnings surprise and excess stock returns.

In their examination of anomalies with regards to the EMH, several behavioural finance studies (Bernard and Thomas 1989, 1990; De Bondt and Thaler 1985, 1987) observe investors' under or over reaction to earnings announcements. Underreaction leads to a post-earnings announcement drift or an upward correction following the EPS release. In the case of an overreaction, or when stock market reaction to the earnings announcement is stronger than expected, a downward correction leads to a reversal of stock prices. Behavioral finance attributes such behavior around earnings announcements to psychological and cognitive biases.

For instance, Daniel et al. 1998 explain underreaction by biased self-attribution and investor overconfidence. Overconfident investors believe that their skills are superior and that other investors' belief revisions are incorrect, which leads them to form expectations at odds with the market. Overconfidence leads investors to neglect public information, especially if it contradicts their beliefs. The Daniel et al. 1998 model challenges the traditional view that securities are rationally priced to reflect all publicly available information. Barberis et al.

1998 explain underreaction to public announcements such as earnings press release by the conservatism bias. This bias means that the subjects tend to underweight recent information by comparison to the information they already hold.

At the opposite, overreaction can be explained by the representativity bias. According to Kahneman, Slovic, and Tversky 1982, individuals may perceive some erroneous tendencies in infrequent announcements. When events are not frequent, investors would tend to overweigh the probability that such an event will occur. This is at the origin of the phenomenon of overreaction.

In summary, stock market reaction to earnings announcements may be weaker or stronger than expected under the EMH. Various psychological biases and emotions are suspected to act as a complement to rationality or moderate the belief revision process of investors and, as a consequence, the stock market reaction. Therefore, post-announcement excess stock returns may not only be driven by the earnings surprise, but also influenced by the investor's emotional response to the earnings surprise. This raises the possibility that traders' emotional response act as a moderator by modifying the rational link assumed under the EMH between earnings surprises and excess stock returns. This leads us to formulate the following hypothesis:

HYPOTHESIS 4. *Traders' emotional response moderates the relationship between the earnings surprise and excess stock returns.*

Our four hypotheses are summarized in Figure 2.

3. Experimental design

The goal of this study is to examine emotions as a complement to rationality in the decision-making process of stock traders when they are exposed to new information. Due to the unconscious nature of emotions (Titah et al., Forthcoming), we assess emotional reaction with

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a non-intrusive psychophysiological measure. Specifically, to measure traders' emotional reaction, we use their electrodermal responses during an experimental setting modeled on a simple but representative financial investment decision. The experiment allows us to focus on earnings announcements and avoid the effect other sources of information may have on investors in the real world.

Sample

Participants were recruited from the subject pool of our institution. Because the task required knowledge of accounting or finance, only graduate students and researchers in these fields were recruited as reasonably good proxies for investors or traders (Libby, Bloomfield, and Nelson 2002; Elliott, Hodge, Kennedy, and Pronk 2007). The final sample includes 24 participants[3] or 379 observations. They were paid a $30 Amazon gift certificate to participate in the study and an additional performance based compensation averaging $15. Real traders are typically provided with performance based incentives. The experimental design was approved by the Institutional Review Board of the researchers' institution.

Experimental task

Our experiment consisted in measuring subject-traders' emotional responses at various stages of their stock trading decision. The multi-trial within-subject experimental protocol presented in Figure 1 exposed each subject, once he had traded based on historical EPS and analyst consensus forecasts (Screen I of the experiment), to genuine earnings announcements components in T2 (Screen II) and actual gains or losses computed and revealed in T3 from contemporary excess stock returns (Screen III ending at the end of each trial). The experiment was repeated for 18 trial firms. Each participant sequentially viewed three screens for each of

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[3] The initial sample included 35 participants, but 11 participants were rejected to do excessive neurophysiological artefacts.

the 18 trials. Eighteen trial firms were randomly selected from the S&P 500 for the year 2012. We insured that the data required for the experiment were available on I/B/E/S and that the trial firms had published an earnings press release to satisfy data requirements.

For each trial firms, the first screen (between T1 and T2) presents the actual EPS and analysts' consensus forecasts for years t-3, t-2 and t-1 and the analyst consensus forecast for year t. The participant was first asked to forecast the EPS of year t. Then, the participants were asked to buy or short-sell the firm's stock on the basis of the financial information provided within a maximum delay of 2 minutes.

The second screen of Figure 1 (T2-T3) presents abstracts of the trial-firms genuine earnings press releases including actual comments by the firm's CFO or CEO as in the real world. The actual, forecasted, historical, and consensus EPS figures occupy the same space as the comments. Earnings or EPS announcements are part of the mandatory information required by the Stock Exchange Commission. They are an important means by which firms communicate to investors about their financial performance, prior to subsequently filing their formal financial statements with the relevant market authorities (Henry 2008). Basu et al. 2013 compare the information content of earnings announcements to dividend announcements, management forecasts, preannouncements, and 10-K and 10-Q filings and their amendments. To that end, they use the R^2 metric of Ball and Shivakumar's 2008: the proportion of the variation in annual returns explained by the four quarterly earnings announcements returns. They find that earnings announcements are a superior information source, in the sense that they convey more information than other information sources individually. A first physiological measure of skin conductance response (SCR) was taken at step T2 reproducing earnings announcements.

In the third screen (from T3 on Fig. 1), participants' investment performance was revealed to them. Their performance was measured by the firm's excess stock return calculated from

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CRSP (Center for Research in Security Prices) three days surrounding the earnings announcement by using the Fama and French (1993) three factor model. Thirty seconds were allowed for the participant to read the information about their performance.

Procedure

Upon arrival, participants were greeted and prepared for the experiment. The same preparation protocol was followed for each participant. Consent forms including a compensation form were also completed during preparation. Participants reported no health or neuro-physiological diagnostics that might have precluded them from participating in our experiment. BioNomadix Wireless EDA sensor (Biopac, Santa Barbara, CA) was used to measure skin conductance.

Once the physiological montage was completed, participants took place in front of the computer which was used for the rest of the experiment. Before the experimental task, the participants completed a computer-based questionnaire to assess their demographics such as gender and academic background, their experience and financial literacy, and their personality and risk tolerance (Carver and White 1994). Before proceeding with the experiment, participants went through one mock-up trial where they benefited from a script that explained the different tasks of the experiment.

ePrime (Psychology Software Tools Inc., Sharpsburgs, PA), stimulus presentation software, was used to present the task described in Figure 1 to the participants. Stimuli presentation was synchronized with BioNomadix Wireless EDA sensor via Noldus Observer XT (Noldus Information Technologies, Wageningen, The Netherlands). Upon completion of the experiment, we were able to match the announcement of earnings and the revelation of gains or losses with synchronous real-time measurements of participants physiological skin

conductance responses. Specifically, ePrime markers T2 and T3 were transferred in the Biopac data timeline via Noldus.

Measures

Dependent variables

Skin conductance response (*SCR-T-5s SCR-T-10s*) at T2 and T3 Subject-traders' emotional responses are measured by their SCR at the time they revise their beliefs following new information. SCR-T2 defines their emotional response to the earnings surprise, and SCR-T3 is the emotional response of participants when they are informed of the gain or loss they made on their buy or sell decision. Similar to Barton (2014), to convert all investment positions into long ones with participants expecting to make gains, we reverse the sign of SCR when participants took a short rather than a long position. SCR takes into account both the amplitude of the response as well as its decay time (5 or 10 seconds) (Naqvi and Bechara 2006: 111).

SCR refers to the increase of secretion of electrolyte solution by eccrine sweat glands in the palm of the hand at the onset of a stimulus. Sweat glands are innervated by the sympathetic branch of the autonomic nervous system. Skin conductance is a reliable index of autonomic nervous system activity, measured by the potential conductance difference between two areas of the skin (Boucsein, 2012). In this paper, we measure skin conductance using two sensors placed in specific location of palm of the hand of our subject: the thenar and hypothenar eminences. Under the skin, eccrine glands secreate electrolyte solution (sweat). These secretions are under the control of the sympathetic division of the autonomic nervous system. The level of electric current flowing between these two electrodes has been used widely in the literature as an objective measure of emotional arousal (Bradley et al., 1993; Lang, 1985). It should be noted that this measure has been argued to be specifically

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appropriate for task involving decision making in a computerized environment because it does not interfere with the natural interaction between the subject and the task (Riedl, Kindermann, Auinger, and Javor 2013). There exist several measures of skin conductance. In this paper, we build upon Naqvi and Bechara 2006 and use the variation of skin conductance that occurs within a discrete window (5 and 10 seconds) following the presentation of a stimulus[4]. To account for both the amplitude of the response and the decay in time, we specifically use the area under the curve of the SCR (SCR.auc), which is referred in the literature as the "quantity of affect" generated by a stimulus (Traxel 1957).

Excess stock returns (cumulative abnormal return - *CAR*) Based on the conventional three-factor model (Fama and French 1993), we estimate the firm's excess stock return over three days surrounding the earnings announcement release date. Excess stock return is used to determine participants' investment performance, which in turn determines if their investment decision led to a gain or a *Loss*. The variable *Loss* is defined below.

Independent variables

Earnings surprise (*Surprise*) We use analysts' consensus forecast as a benchmark to compute the earnings surprise. The earnings surprise is the difference between the actual EPS and analysts' EPS forecast consensus, divided by analysts' forecast consensus. The consensus is calculated as the mean analysts' forecast issued after the announcement of last-year EPS and before the announcement of current-year EPS.

Loss **(or gain)** *Loss* is a dummy variable coded 1 when the subject's investment decision results in a loss, and 0 in the case of a gain. A loss occurs in the case of a buy decision when earnings fall short of expectations or in the case of a sell decision when earnings beat

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[4] Naqvi and Bechara 2006 (193) use the example of Skin conductance response to winning play money. The skin conductance response interval begins 1 sec. after stimulus onset and ends 5 sec. after stimulus onset. They note that, although the peak of the response may occur outside of this interval, the response must initiate within this interval. To account for this, we took two measurements at 5 and 10s. Each task marker T2 and T3 are 1 sec. long.

expectations. A gain is realized in the case of a buy decision when earnings exceed expectations or in the case of a sell decision when earnings fall short of expectations.

Control variables

We also control for other variables likely to affect the emotional response of investors such as their personality and risk tolerance, their gender, and their professional experience. These data were collected with the help of a questionnaire participants had to fill before the experiment.

Personality and risk tolerance (*BIS* or *BAS*) The personality and risk taking preference of participants were measured by the standardized BIS/BAS metrics, a validated measurement scale of an individual innate affective response to reward and punishment (Carver and White 1994). According to Gray's 1981 theory of brain functions and behavior, the BIS (Behavioral inhibition system) scale measures a person's sensitivity to punishment or absence of reward while the BAS (Behavioral activation system) scale measures a person's sensitivity or impulsiveness to rewards. So, in our experiment, greater BAS sensitivity should be reflected in greater proneness or less risk aversion when exposed to cues of impending reward. An investor with high BIS should experience stronger negative feelings like anxiety and withdrawal (high risk aversion) when a firm he is invested in reports earnings that miss his expectations. An investor with high BAS should exhibit stronger emotions when a firm reports earnings that beat his expectations. We use participants' BIS/BAS measures as control variables in our analyses.

Experience The skills and experience of traders may affect their financial decision making. This variable is coded 1 (0 otherwise) if the participant has experience or training in investment or finance.

Gender According to Coates, Gurne, and Sarnyai 2010, males and females have very different endocrine systems which may influence their propensity for risk-taking. This variable is coded 1 in the case of a man and 0 in the case of a woman.

4. Results and interpretations

Descriptive statistics

Table 1 presents the descriptive statistics of the measures. As hypothesized, the existence of positive SCR indicates that participants emotionally react to financial information. In the case of the earnings announcement (H_1; SCR-T2), the mean amplitude of participants' emotional response to earnings surprise is 0.166 for the 5-second window and 0.053 for the 10-second window. When they learn about their investment performance, the average of participants' emotional response (*H2*; SCR-T3) is higher than in the case of earnings announcement for both 5-second (0.207) and 10-second (0.075) windows. This indicates that the emotional response is lower when accounting earnings are announced then when the subject is informed of his performance based on market figures. As SCR also takes into account the decay of emotions in time, the higher emotional responses observed in the 5-second window than in the 10-second window for both earnings and investment performance indicates that subjects quickly react to financial information.

The average earnings surprise (*Surprise*) to which the subjects were exposed is -0.014 while the average cumulative abnormal stock return (*CAR*) is -0.013. About 41% of the investment decisions made by participants resulted in a profit. The average score of variable BIS (2.441) is relatively higher than the one of BAS (2.196). It seems that participants were more sensitive to punishment and more risk averse, which appears in line with Prospect theory. Sixty-three percent of participants were males and 65% of them had some limited experience.

[Table 1 about here]

Correlation analysis

Table 2 shows the Pearson correlation coefficients. As hypothesized in H_2, the positive association between the cumulative abnormal stock returns (*CAR*), a proxy for investment performance and the emotional response of the participants indicates that a trader's gain or loss significantly influences his emotional response. The relation is significant at 1% for *SCR-T3-5s* and at 10 % for *SCR-T3-10s.* Although positive as hypothesized, the relation between the earnings surprise and the trader's emotional response (H_1) is only statistically significant when the response is measured with a window of 10 seconds (SCR-T3-10s). As hypothesized, the dummy variable *Loss* is generally positively related to the emotional response (H_3). It seems that unfavourable investment results may lead to higher emotional responses in accordance with Prospect theory.

Participants' financial experience (*Experience*) is negatively related to their emotional response to earnings surprise when it is measured over a window of 10 seconds (*SCR-T2-10s*). The more experienced participants seem to be less emotional when exposed to an earnings surprise. Furthermore, the negative relationship between *Experience* and *BIS* suggests that participants with more financial experience are more sensitive to punishment, and less sensitive to reward. The low correlation coefficients between explanatory variables as well as the variance inflation factor (VIF) values reported in Tables 3 and 4 suggest that multicollinearity is not a serious threat to our multivariate analysis, which we present in the next sub-section.

[Table 2 about here]

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Multivariate analysis

We first examine investors' emotional response at the time of the earnings announcement and when they learn about their investment performance. To test Prospect theory, we then refine our analysis by examining whether the emotional response is the same in a gain as in a loss situation.

Traders' emotional response to earnings surprise

Table 3 (Panel A) presents the results of the random effect regression model used to test Hypothesis 1 on the relation between earnings surprises and investors' emotional responses. We find that the variable *Surprise* is positively related to the emotional response. However, the relation is not significant at conventional levels which could be attributed to the low average level of earnings surprise presented in Table 1. Hypothesis 2 is used to examine investors' emotional responses when they are informed of their investment performance at T3 based on cumulative abnormal stock returns (*CAR*) around earnings announcement. Panel B of Table 3 presents the impact of *CAR* on the emotional response at T3. The positive and significant coefficient of *CAR* indicates that the magnitude of the investment performance (gain or loss) is related to the variation of investor's emotional response. This result supports Hypothesis 2. In summary, traders emotional response is significant when informed of their investment performance based on market values while their response, although positive, is not significant when accounting earnings are announced. Consistent with the results of the earlier correlation analysis, we find that the variable *BIS* is negatively related to the amplitude of emotional response.

The analysis presented in Panel C of Table 3 refines the previous one by introducing a dummy variable (*Loss*) translating whether or not the participants realized a loss (=1) or a gain (=0) on their investment decision. The objective is to test Prospect theory and investigate

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whether traders' emotional response is the same when they learn that they realized a loss or a gain, following their buy or sell decision. In conformity with theory and Hypothesis 3, we find that Loss is positively and significantly related to the emotional response in the interval of 10 seconds after subjects are informed of their investment performance (*SCR-T3-10s*). The model controls for the effect of the investment performance (*CAR*), which remains significant in both 5 and 10 seconds intervals. We also controlled for the personality and risk tolerance (*BIS* and *BAS*), Gender and Experience of the subjects. It is particularly important to control for the innate *BIS* and *BAS* of the subjects as they respectively represent the subjects' sensitivity to punishment and rewards. This result suggests that bad investment performance induce stronger emotional response in line with Prospect theory according to which individuals are more sensitive to loss than gains.

[Table 3 about here]

Traders' emotions and the stock market reaction to earnings surprise

A fourth hypothesis is used to investigate whether traders' emotional response has a moderating effect on the stock market reaction to earnings surprise as measured by excess or cumulative abnormal stock returns (*CAR*). Not surprisingly both models presented in Table 4 show that the earnings surprise is positively related to *CAR*. This relation is significant at the 1% level and consistent with the market efficiency rationality hypothesis suggesting that stock prices incorporate new information released in the financial market.

To test whether traders' emotional response has a moderating effect on the relationship between earnings surprise and the market reaction, a variable representing the interaction between earnings surprise and emotional response is introduced in models 1 and 2 of Table 4. As hypothesized, this interaction variable is positively and significantly associated to the market reaction indicating that investor's emotional response moderates the relationship

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between earnings surprise and market reaction. Although the association is only weakly significant at 10%, this result is in line with the anomalous evidence revealed in behavioural finance (Shiller 2003) regarding market efficiency such as observed investors' under or over reaction to earnings announcements.

[Table 4 about here]

5. Conclusion

The dominant view in accounting and finance research is that investors are rational and markets efficient and that, on average, there is no room for emotions. Despite the efforts of behavioural finance which challenges those assumptions, prior research based on archival or self-reported data has not opened the "black box" of the role of emotions in investors' beliefs revision, a crucial intermediary between information and market prices. In this study, we take a different approach from the existing literature to revisit the question as to how investors form and revise their beliefs or expectations which are captured in stock returns. We address this fundamental behavioural research question in a multi-trial within-subject experiment where a physiological automatic measure of traders' emotional responses is used to determine whether their emotions complement rationality in their belief revisions and investment decisions around earnings announcement. We also investigate the moderating role traders' emotions may play in the expected "rational" relation between earnings announcement and excess stock returns.

More precisely, we observe the decision-making process of traders by measuring their electrodermal response, a proxy for emotional response, during an experiment modeled on a simple but representative investment decision. First, we test whether traders emotionally respond to earnings announcements. We find that there is no immediate significant emotional response to earnings surprise when the earnings accounting figure is announced but there is an

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emotional response when the trader learns about his investment performance which is based on market data. Moreover, in accordance with Prospect theory, we find that a loss or a negative investment performance is likely to lead to a stronger emotional physiological response than a gain.

Second, we investigate whether traders' emotions affect their belief revisions or if they moderate the market reaction to earnings surprise. As stock returns capture investors' belief revisions and as their emotional response is essentially a psychophysiological measure of the earnings surprise, we expect it to affect the market reaction to earnings announcements. This would be consistent with the literature in financial accounting showing a positive association between earnings surprise and stock returns. Our empirical results indicate that, as hypothesized, investors' emotional response moderate the positive relation between earnings surprise and the stock market reaction. Although weak, this last result appears contrary to the predicaments of the efficient market hypothesis.

These findings have several implications for theoretical and empirical accounting research. First, we provide theoretical and empirical evidence that traders' emotions may represent a potential omitted variable in the stream of research assuming that investors only react rationally to new information. Our results suggest that traders emotionally respond to financial information concerning their investment performance and that their reaction is more intense when the performance is negative.

Second, contrary to the traditional efficient market hypothesis (Samuelson 1965; Fama 1970) and in accordance with the proponents of behavioral finance (Shiller 2003; Kahneman and Tversky 1979), we provide some theoretical explanations and empirical evidence suggesting that emotions do play a role in traders' decision making. We observed that our subjects' emotional reaction moderates the relationship between earnings surprise and stock returns.

Third, this study contributes to the emergent subfield of neuroaccounting (Birnberg and Ganguly 2012) by using a psychophysiological method to more objectively assess traders' emotional reactions involved in their decision making process. The addition of this type of methods to accounting and finance research provides researchers with tools than can assess internal processes with greater validity than self-reported research methods, because they are less subject to respondents' judgment or memory biases (Titah et al., Forthcoming).

Our findings also suggest implications for managers and regulators. By observing emotional reactions at various stages during the decision making process, our results better inform managers on the potential reactions of traders following specific announcements. This could help managers anticipate the market reaction. Finally, for regulators responsible for the quality of the financial reporting system, the evidence from this study suggests that investors' do have emotional reactions especially when their performance is lower than anticipated. This departure from the efficient market hypothesis (EMH) could have implications for future regulation of similar types of disclosures.

As with all scientific inquiry, limitations need to be acknowledged. First, we opted to assess emotional reactions with electrodermal activity. In order to replicate our findings and test their external validity, future studies may use additional psychophysiological measurements, such as cardiovascular measures, facial expression and electroencephalographic signals to enrich our understanding of the underlying state of the trader. In addition, our sample was composed of graduate students from one business school, a reasonably good proxy for investors or traders (Libby et al. 2002; Elliott et al. 2007). Future research should be performed using samples with different characteristics. Finally, although participants were compensated partially based on their performance to ensure a more realistic involvement in

the experimental task, their own money was not at stake. Additional studies involving participants' own money should be performed to test if results are the same in this situation. We suggest that emotional reactions would be even greater if involvement was increased.

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Figure 1 Multi-trial within-subject experimental protocol
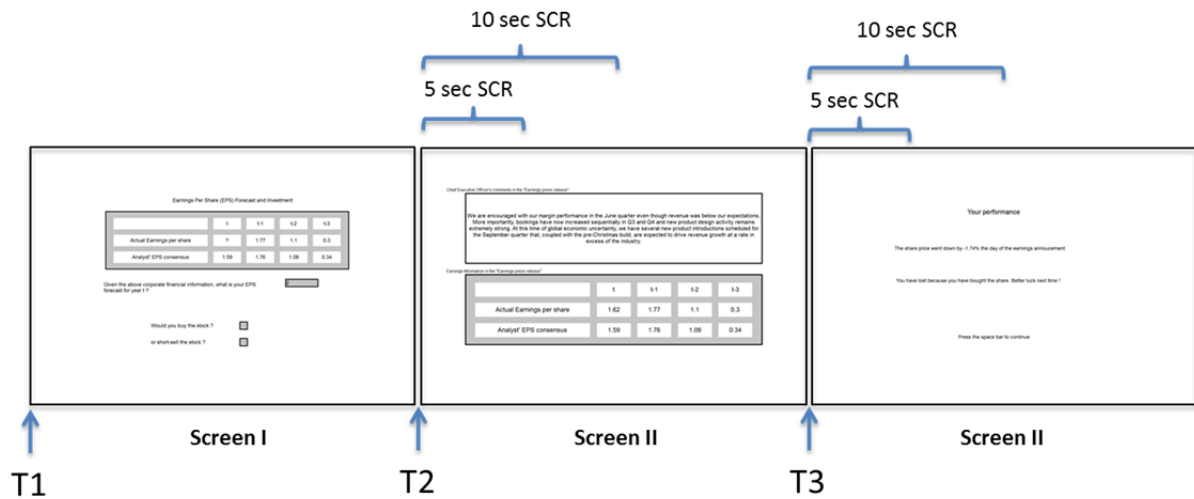
Screen 1
Given actual earnings per share (EPS) for t_{-1}, t_{-2} and t_{-3} and analysts' consensus forecasts for t, t_{-1}, t_{-2} and t_{-3}, subject-investors are asked to forecast firm's EPS in t and make a buy or short-sell investment decision.

Screen 2
Subject-investors are exposed to an abstract of the firm's press release where the actual EPS is announced.

Screen 3
Subjects are informed of their investment performance as measured by the firm's excess stock return. Experiment was repeated for 18 trial firms randomly selected from the S&P 500 for the year 2012.

Figure 2 Emotional response to financial information
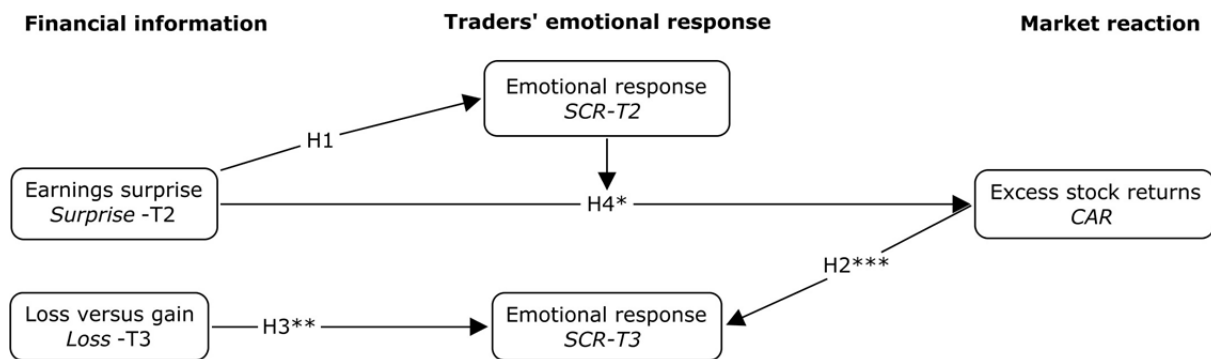
Hypotheses

H1: Traders' emotional response is positively related to the earnings surprise.

H2: Traders' emotional response is positively related to excess stock returns.

H3: Traders' emotional response is stronger in the case of a loss compared to a gain.

H4: Traders' emotional response moderates the relationship between the earnings surprise and excess stock returns.

Notes:

- Conceptual or theoretical variables in **bold** characters.

- *SCR-T2*: Emotional response to the earnings surprise (T2) as measured by their skin conductance response.

- *SCR-T3*: Emotional response to the investment performance (T3).

- *Surprise*: Earnings surprise is the difference between the actual EPS and analysts' EPS forecast, divided by analysts' forecast consensus.

- *Loss* is a dummy variable coded 1 when the subject's investment performance results in a loss, and 0 in the case of a gain. A loss occurs in the case of a buy decision when earnings fall short of expectations or in the case of a sell decision when earnings beat expectations. A gain is realized in the case of a buy decision when earnings exceed expectations or in the case of a sell decision when earnings fall short of expectations.

- *CAR*: Cumulative abnormal return calculated over a conventional window of three days surrounding earnings announcement.

***, **, *: Relation statistically significant at 1, 5 and 10 % respectively.

TABLE 1
Descriptive statistics

	Mean	Median	S.D.	Min.	Max.
SCR-T2-5s	0.1664	0.0168	1.1522	-7.6511	9.2962
SCR-T2-10s	0.0534	0.0150	0.4501	-2.8001	4.0050
SCR-T3-5s	0.2065	0.0282	1.4528	-6.2631	7.7011
SCR-T3-10s	0.0752	0.0331	0.5418	-3.6847	3.9769
Surprise	-0.0137	-0.0047	0.0398	-0.1346	0.0417
CAR	-0.0128	-0.0170	0.0490	-0.1369	0.0756
Loss	0.5886	1.0000	0.4928	0.0000	1.0000
BIS	2.4405	2.0000	0.8878	1.3333	4.0000
BAS	2.1962	2.1667	0.6123	1.1667	3.6667
Gender	0.6294	1.0000	0.4836	0.0000	1.0000
Experience	0.6458	1.0000	0.4789	0.0000	1.0000

Number of observations: 367

Variables:
SCR-T2-5s and *SCR-T2-10s*: Emotional response to the earnings surprise (T2) as measured by their skin conductance response within 5 and 10 seconds windows, respectively. *SCR-T3-5s* and *SCR-T3-10s*: Emotional response to the investment performance (T3) within 5 and 10 seconds windows, respectively. *Surprise*: Earnings surprise is the difference between the actual EPS and analysts' EPS forecast, divided by analysts' forecast consensus. *Loss*: Dummy variable coded 1 in the case of a loss, and 0 in the case of a gain. *CAR*: Cumulative abnormal return calculated over a conventional window of three days surrounding earnings announcement. *BIS*: Behavioral inhibition system measures a person's sensitivity to punishment or absence of reward. *BAS*: Behavioral activation system measures a person's sensitivity or impulsiveness to rewards. *Experience*: Dummy variable coded 1 if the participants have financial skills or experiences. *Gender*: Dummy variable coded 1 in the case of a man and 0 in the case of a woman.

TABLE 2

Pearson correlation coefficients between variables

Variable		<1>	<2>	<3>	<4>	<5>	<6>	<7>	<8>	<9>	<10>
<1>	SCR-T2-5s	1.0000									
<2>	SCR-T2-10s	0.4994 ***									
<3>	SCR-T3-5s	0.5998 ***	0.3342 ***								
<4>	SCR-T3-10s	0.4185 ***	0.7647 ***	0.4908 ***							
<5>	Surprise	0.0094	0.0537	0.0417	0.1029 **						
<6>	CAR	0.0490	0.0641	0.1405 ***	0.1010 *	0.2224 ***					
<7>	Loss	0.1321 **	0.1456 ***	0.0730	0.1285 **	0.1341 **	-0.0569				
<8>	BIS	-0.0808	-0.0991 *	-0.1121 **	-0.0754	-0.0211	-0.0355	-0.0218			
<9>	BAS	0.0123	-0.0018	0.0341	0.0289	-0.0191	-0.0345	0.0434	0.3217 ***		
<10>	Gender	0.0396	0.0616	-0.0292	0.0431	-0.0182	-0.0145	0.0578	0.3197 ***	0.4169 ***	
<11>	Experience	-0.0678	-0.1219 **	-0.0403	-0.0389	0.0097	-0.0101	-0.0288	0.4772 ***	-0.0031	0.0687

Number of observations: 367.

 *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively.

Variables:
SCR-T2-5s and *SCR-T2-10s*: Emotional response to the earnings surprise (T2) as measured by their skin conductance response within 5 and 10 seconds windows, respectively. *SCR-T3-5s* and *SCR-T3-10s*: Emotional response to the investment performance (T3) within 5 and 10 seconds windows, respectively. *Surprise*: Earnings surprise is the difference between the actual EPS and analysts' EPS forecast, divided by analysts' forecast consensus. *Loss*: Dummy

variable coded 1 in the case of a loss, and 0 in the case of a gain. *CAR*: Cumulative abnormal return calculated over a conventional window of three days surrounding earnings announcement. *BIS*: Behavioral inhibition system measures a person's sensitivity to punishment or absence of reward. *BAS*: Behavioral activation system measures a person's sensitivity or impulsiveness to rewards. *Experience*: Dummy variable coded 1 if the participants have financial skills or experiences. *Gender*: Dummy variable coded 1 in the case of a man and 0 in the case of a woman.

TABLE 3
Regression of Traders emotional response on Earnings surprise

	Random Effects Regressions					
Panel A: Hyp. 1	SCR-T2-5s			SCR-T2-10s		
	Coeff.	z		Coeff.	z	
Intercept	0.3477	*1.38*		0.1860	*1.91*	*
BIS	-0.1207	*-1.42*		-0.0415	*-1.26*	
BAS	0.0285	*0.25*	*	-0.0127	*-0.29*	
Gender	0.1552	*1.1*		0.0951	*1.75*	*
Experience	-0.0671	*-0.46*		-0.0850	*-1.5*	
Surprise	0.2652	*0.18*		0.6150	*1.05*	
R² within	<0.0001			0.0032		
R² between	0.2608			0.2683		
R² overall	0.0123			0.0284		
Prob > chi2	0.4825			0.0612		
VIF	<1.6			<1.6		

Table 3 – Regression of Traders' emotional response on Excess stock returns

Panel B: Hyp. 2	SCR-T3-5s			SCR-T3-10s		
	Coef.	z		Coef.	z	
Intercept	0.3245	*1.04*		0.1203	*1.02*	
BIS	-0.2396	*-2.27*	**	-0.0673	*-1.69*	*
BAS	0.2265	*1.62*		0.0374	*0.71*	
Gender	-0.0673	*-0.39*		0.0689	*1.05*	
Experience	0.0996	*0.55*		0.0120	*0.18*	
CAR	4.1077	*2.68*	***	1.0999	*1.91*	*
R² within	0.0194			0.0107		
R² between	0.3722			0.2736		
R² overall	0.0385			0.0218		
Prob > chi2	0.0130			0.1532		
VIF	<1.6			<1.6		

TABLE 3
Relations of Traders' emotional response on *Loss*

Panel C: Hyp. 3	SCR-T3-5s			SCR-T3-10s		
	Coef.	z		Coef.	z	
Intercept	0.1985	*0.61*		0.0418	*0.35*	
BIS	-0.2336	*-2.21*	**	-0.0635	*-1.61*	
BAS	0.2207	*1.58*		0.0338	*0.65*	
Gender	-0.0811	*-0.46*		0.0603	*0.92*	
Experience	0.1020	*0.56*		0.0135	*0.2*	
Loss	0.2257	*1.48*		0.1406	*2.46*	**
CAR	4.2363	*2.77*	***	1.1800	*2.06*	**
R² within	0.0246			0.0301		
R² between	0.3558			0.2391		
R² overall	0.0443			0.0380		
Prob > chi2	0.0105			0.0272		
VIF	<1.6			<1.6		
Number of observations 367						

*, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively.

Variables:
SCR-T2-5s and *SCR-T2-10s*: Emotional response to the earnings surprise (T2) as measured by their skin conductance response within 5 and 10 seconds windows, respectively. *SCR-T3-5s* and *SCR-T3-10s*: Emotional response to the investment performance (T3) within 5 and 10 seconds windows, respectively. *Surprise*: Earnings surprise is the difference between the actual EPS and analysts' EPS forecast, divided by analysts' forecast consensus. *Loss*: Dummy variable coded 1 in the case of a loss, and 0 in the case of a gain. *CAR*: Cumulative abnormal return calculated over a conventional window of three days surrounding earnings announcement. *BIS*: Behavioral inhibition system measures a person's sensitivity to punishment or absence of reward. *BAS*: Behavioral activation system measures a person's sensitivity or impulsiveness to rewards. *Experience*: Dummy variable coded 1 if the participants have financial skills or experiences. *Gender*: Dummy variable coded 1 in the case of a man and 0 in the case of a woman.

TABLE 4
Relation of Excess stock returns on the interaction between Traders emotional response and *Surprise*

Hypothesis 4	Model 1 Coef.	z		Model 2 Coef.	z	
Intercept	-0.0091	*-3.41*	***	-0.0094	*-3.55*	***
Surprise	0.2959	*4.62*	***	0.2995	*4.63*	***
SCR-T2-5s	0.0033	*1.45*				
SCR-T2-5s*Surprise	0.1334	*1.69*	*			
SCR-T2-10s				0.0115	*1.8*	*
SCR-T2-10s*Surprise				0.2802	*1.84*	*
R² within	0.0581			0.0616		
R² between	0.5766			0.1915		
R² overall	0.0591			0.0609		
Prob > chi2	<0.0001			<0.0001		
VIF	<1.2			<1.4		
Number of observations: 367						

*, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively.

Variables:
SCR-T2-5s and *SCR-T2-10s*: Emotional response to the earnings surprise (T2) as measured by their skin conductance response within 5 and 10 seconds windows, respectively. *SCR-T3-5s* and *SCR-T3-10s*: Emotional response to the investment performance (T3) within 5 and 10 seconds windows, respectively. *Surprise*: Earnings surprise is the difference between the actual EPS and analysts' EPS forecast, divided by analysts' forecast consensus. *Loss*: Dummy variable coded 1 in the case of a loss, and 0 in the case of a gain. *CAR*: Cumulative abnormal return calculated over a conventional window of three days surrounding earnings announcement. *BIS*: Behavioral inhibition system measures a person's sensitivity to punishment or absence of reward. *BAS*: Behavioral activation system measures a person's sensitivity or impulsiveness to rewards. *Experience*: Dummy variable coded 1 if the participants have financial skills or experiences. *Gender*: Dummy variable coded 1 in the case of a man and 0 in the case of a woman.