# Emotions and market activity: Cause or consequence?

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**Abstract:** Many observers have asserted that there is a correlation between emotions and asset market behavior. In this paper, we conduct laboratory experiments to examine the causality in this relationship. The results show that incidental emotions, induced by VR videos, do not influence market prices. However, there is a strong relationship between market activity and subsequent emotional states, suggesting that the correlation between emotions and market activity is driven primarily by market activity influencing emotions, not the other way around.

## 1 Introduction

The connection between asset market behavior and emotional states is intuitive to many observers. Market commentators frequently make this link, associating joy (or excitement/exuberance) with high prices and fear with low and volatile prices. Following the 1929 stock market crash, Irving Fisher (1930) attributed the crash to an unjustified *panic* on the part of investors. In 1996, the Chairman of the Federal Reserve Bank, Alan Greenspan, after a strong runup that year, remarked "But how do we know when *irrational exuberance* has unduly escalated asset values, which then become subject to unexpected and prolonged contractions…" (Greenspan, 1996). Warren Buffett, one of the world's most prominent investors, in a widely read New York Times editorial "be *greedy* when others are *fearful* and fearful when others are greedy" (Buffett, 2008). On January 22, 2024, the New York Post asserted "Steel yourself — the stock market is *irrationally exuberant* again" (Rosenberg, 2024). There are a number of "*Fear* Indices" which are measures of variability in the stock market. In all these cases, positive emotions are associated with higher prices and the negative emotion of fear with low prices and higher volatility.

Distinguished academic observers have made remarks along the same lines. For example, Galbraith

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(1984) describes stock market price bubbles as "*speculative euphoria*". Shiller (2000), when describing the phenomenon of asset price bubbles, states "… I define a speculative bubble as a situation in which news of price increases spurs investor *enthusiasm* … bringing in a larger and larger class of investors who, despite doubts about the real value of an investment, are drawn to it partly by *envy* of others' successes and partly through a gamblers' *excitement*". During an appearance on CNBC, Krugman (2020) commented "When you look at the way that people have piled into the stocks of bankrupt companies like Hertz there's clearly something, a bit of *mania* going on. It's very hard to escape the sense that there's mania now, that this is a FOMO market."

These observers are not precise on whether they believe that the relationship between emotions and market behavior is correlational or causal, though most seem to suggest that the causality runs from emotions to market behavior. There does seem to us to exist a sound intuition for why higher market prices would lead to positive emotions since the paper wealth of investors typically increases when prices go higher. Lower prices would presumably lead to negative emotional states as investors incur losses in paper wealth. One of these emotional states might be fear as individuals worry that the decrease in wealth might affect their future consumption. However, the mechanism for the reverse causal relationship, whereby emotional state would cause asset price movements, as the commentators seem to suggest, is not obvious.

In this paper, we investigate the direction of the causality between emotional state and market prices. We conduct a new direct test of whether a positive emotional state increases asset prices and whether fear lowers them. There are three treatments: Happy, Fearful, and Neutral, corresponding to the emotional state that is induced at the outset of the sessions. Emotions are induced with the use of 360-degree videos shown in virtual reality using wireless headsets. The effectiveness of the videos we use in inducing the desired emotions has been established in prior studies (Kugler et al., 2020; Medai and Noussair, 2021; Nguyen and Noussair, 2022) and is revalidated with a manipulation check with our participants. We believe that the methodology of virtual reality, with its immersive experience, provides a more intense emotion induction than traditional methods.

After the emotion induction, participants trade in a continuous double-auction market, where they exchange shares of an asset that pays a stochastic dividend. In some sessions there is only one market, and in other sessions there are two consecutive markets. We compare the price and trading volume of the shares across treatments. We hypothesize that the Happy treatment would lead to higher prices and that the Fearful condition would generate lower prices.

We then consider the reverse directional relationship, the effect of market activity on emotional state. We include surveys at the beginning and at the end of the first market to measure the change emotional state of traders while the market is operating. We hypothesize that those who earn more in the market experience an increase in happiness and a decrease in fear relative to those who earn less.

We find that inducing emotional states does not affect prices or quantities traded in the market. There is also no evidence that inducing happiness causes people to make more purchases, or that fear causes them to sell more. The amount of trading activity is unrelated to emotional state. However, there is a strong relationship between market activity and *subsequent* emotional state, suggesting that this is the main factor creating the correlation between emotions and market prices. The findings lead us to the conjecture that higher market prices, which typically indicate greater trader earnings, lead to happy/exuberant emotional states, rather than the other way around.

## 2 Related literature

The correlation between aggregate societal measures of emotional state and asset price movements is well-established in empirical work. Bollen et al. (2011) find that Twitter mood predicts subsequent stock market movements. Gilbert and Karahalios (2010) report that the level of anxiety of posts on the blog site Live Journal predicts price declines. Griffith et al (2020), studying a 24-hr rolling average score of references in the news and social media, find that fear, gloom and stress predict negative market returns and joy predicts positive returns. Subramanian and Chakraborty (2021) observe that values of a Covid-19 fear index constructed from Google trends correlates negatively with stock returns. Edmans et al. (2022) observe that when more happy songs are listened to on Spotify the stock market performs better.

There are some research studies that report causal relationships, where an exogenous event that affects stock prices is presumed, though not shown, to affect the emotional state of traders. Hirshleifer and Shumway (2003) find that stock returns are higher on sunny days. Kamstra, Kramer and Levi (2003) find that returns are higher in seasons with more daylight. Shafi and Mohammadi (2020) observe that investors contribute less crowdfunding on cloudy days. Edmans et al. (2007) find that losses of a national team in important international soccer matches lower stock returns. Curatola et al. (2016) replicate the effect with World Cup matches specifically. All five studies interpret their results as showing that emotions affect prices but provide no direct of independent evidence for this channel. In our view, the price effects

observed in these studies could reflect a change in market value without emotions or mood of market participants being involved at all. Good weather or a sport victory presumably causes a positive mood on the part of investors, but it can also affect the profitability of business as people may go out and spend more when the weather is good or to celebrate a victory. In response, asset prices might increase even if the traders' emotional state is unaffected.

A number of prior laboratory experimental studies have investigated related issues. Lahav and Meer (2012) conducted the first experiment, to our knowledge, to study the connection between emotions and markets. Their experimental design consisted of two treatments, Positive and Neutral. In the Positive treatment participants viewed a 5-minute comedy video, while in the Neutral treatment, there was no video. They then traded in a market of the type introduced by Smith et al. (1988), which is known to produce price bubbles. They observed higher prices in the Positive than in the Neutral condition. Their results are based on four total sessions, so we view their findings as suggestive rather than conclusive. Andrade et al (2016) conduct a similar experiment, and show videos designed to induce different emotions. They study the effect of excitement and of calm relative to a control condition with a neutral video. They observe higher prices in their Excitement condition than in the other two treatments. However, Huber et al. (2024) were unable to replicate this finding with a larger sample and instead found no effect of excitement on price levels. In our view, the question of whether emotional state causally affects market outcomes remains open.

There is also some prior experimental work correlating emotional state and market outcomes. Breaban and Noussair (2013) use FaceReader technology to track emotional states as manifested in facial expressions in the well-known experimental paradigm of Smith et al. (1988). They find that the overall valence of emotional state of the participants before the market opens predicts higher prices, while fear predicts lower prices. An increase of fear in the facial expression of a trader predicts that the trader will make a sale in the next 5 seconds. Bossaerts et al. (2024) investigate the role of heart rate variability in trader performance. Earnings are higher for participants whose heart rate changes anticipate their order submissions, and lower for those whose heart rate responds to their trades.

An asset is in essence a risky lottery. The experimental results regarding how emotional state affects the willingness to take risks are mixed and have led to competing theories. One view is that a positive emotional state causes a greater appetite for risk, and a negative state increases risk aversion. Tversky and Johnson (1983) propose the Affective Generalization Hypothesis, which asserts that a positive emotional state leads to more optimistic beliefs about the outcomes of random events, and thus increases observed

risk taking. On the other hand, the Mood Maintenance Hypothesis (Isen, 1987) claims that a positive emotional state leads an individual to attempt to preserve their current situation, and thus avoid risk taking. Empirical studies have supported both models and there is no consensus on the relationship between emotions and risk taking.

In finance, many prior interesting studies consider an association between market sentiment and asset prices. For example, Da et al. (2015) study Internet search data from the US and find that mentions of negative economic terms, such as "recession", "unemployment", and "bankruptcy" predict decreases in returns and increases in volatility. Jacoby et al. (2024) document a similar relationship for more recent data from China. Huang et al. (2015) propose an index of investor sentiment that predicts cross-sectional stock returns. However, in these studies, sentiment is referring to beliefs about the performance of the asset rather than emotional states. In our work, we are interested in the impact of the emotional state of traders as distinct from their beliefs about the economy.

# 3 Experimental design

## 3.1 Procedures

Each session began with a 10-minute practice period during which subjects learned to trade in a computerized double auction market (Smith, 1962) using the Z-Tree platform (Fischbacher, 2007). In this practice period, there were no incentives. After this practice period, they completed an abbreviated PANAS-X survey (Watson and Clark, 1994) in which they indicated how strongly they currently felt various emotions on a scale of 1 (not at all) to 5 (extremely strong). The survey allows several emotional indexes, including joviality, fear, hostility, and sadness, to be constructed (see Appendix B).

Subjects were then shown a video, which differed by treatment. To view their video, subjects put on Oculus Quest™ virtual reality headsets. The videos are fully immersive and shown in 360 degrees from the point of view of the subject. In the Neutral treatment, all subjects viewed a field of flowers from the perspective of an observer seated in the middle of the field. In the Happy treatment, the individual was surfing in the South Pacific among large waves with tropical islands in the background. The Fearful treatment placed individuals on a tightrope walking across a deep canyon.[1] The same videos have been

[1] As of this writing, the videos can be found at https://www.youtube.com/watch?v=MKWWhf8RAV8 (Happy) https://www.youtube.com/watch?v=JtAzMFcUQ90 (Fearful), and https://www.youtube.com/watch?v=SmhuzTzUKQY

successfully employed to induce emotions in a number of other studies (Kugler et al, 2020; Noussair and Seaback, 2023). After the video, subjects completed the PANAS-X survey the second time, with the questions randomly ordered. Comparison of the responses on the first and second surveys allows us to verify that the videos created the intended emotions without generating other, unwanted emotions.

Next, subjects participated as traders in a 15-minute market for an asset. Trading was in terms of experimental currency (called francs), which was convertible to US Dollars at the end of the experimental session at an exchange rate of 300 francs per dollar. Traders were endowed with 2250 francs and 3 shares of the asset. At the end of the market, each share of the asset paid a one-time dividend $d$ drawn from {20, 44, 104, 200}, with each value equally likely. As the dividend was the only intrinsic value of the share, the fundamental value of one share was equal to the expected value of the dividend, $E(d) = 92$.

Continuous double auction rules were in effect in the market. To trade a share, traders could both post bid and ask offers in real time, as well as accept offers that other traders submitted. When an offer was accepted, a transaction was made, and the transaction price was displayed on the computer screen for all other traders to see. A trader could trade as frequently as they desired, as long as they had sufficient money and shares to complete the trade. A trader's final earnings equaled their original money endowment, plus the dividends earned from shares, plus the net profit from the purchase and sale of shares.

After the close of trading, subjects were informed of their earnings in the market. They then completed the PANAS-X survey for the third time, and finally a questionnaire regarding their demographics. Comparison of the first and third surveys allow us to measure the effect of activity in the market on each subject's emotional state.

In Series 1 of the sessions, conducted in 2021 and 2022, the above constituted the totality of activity in a session. In Series 2, conducted in 2024, subjects had another trading period after the third PANAS-X survey. In this second market, the starting endowments were reinitialized at the same levels as in Market 1. The dividend distribution was also the same in the two markets. Figure 1 illustrates the sequence of events in each session.

(Neutral).

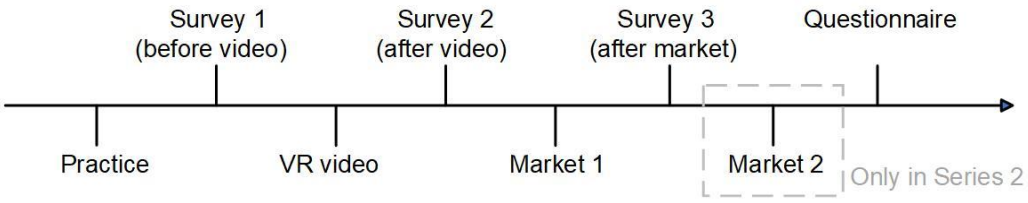



Figure 1. Timeline of the experiment

The sessions were conducted at the Economic Science Laboratory at the University of Arizona. All 247 participants were undergraduate students at the university; males constituted 53.4% of subjects. Participants were recruited via an online system. Each individual was only allowed to participate in one session. Between 5 and 8 participants took part in each session (see Table 1 for more details). Series 1 consisted of 18 sessions, 6 sessions for each treatment, and each session lasted on average 40 minutes. Participants earned an average of 18.6 dollars. Series 2 consisted of a total of 15 sessions, 5 for each treatment. On average each session lasted 65 minutes. Participants earned 21.9 dollars on average, including a 5-dollar show-up fee.

Table 1. Summary of the experimental sessions

| | Experiment time | Average completion time (minutes) | Average earnings (dollars) | Treatments | Number of sessions | Number of participants |
|---|---|---|---|---|---|---|
| Series 1 | Fall 2021 & Spring 2022 | 40 | 18.6 | Happy | 6 | 44 |
| | | | | Fearful | 6 | 48 |
| | | | | Neutral | 6 | 43 |
| Series 2 | Fall 2024 | 65 | 21.9 | Happy | 5 | 38 |
| | | | | Fearful | 5 | 37 |
| | | | | Neutral | 5 | 37 |

## 3.2 Hypotheses

The experiment is designed to test the following two hypotheses regarding the causal relationship between emotions and market activity. As described in Section 1, a number of previous studies and much commentary have suggested that positive emotions on the part of traders would cause higher prices. The first hypothesis is that our treatments would exhibit price differences reflecting this effect.

**Hypothesis 1.** *In Market 1, prices are the highest under Happy, followed by Neutral, followed by Fearful.*

Our second hypothesis is that there is also a causal relationship in the opposite direction. Greater earnings cause a greater level of positive and a lower level of negative emotions.

**Hypothesis 2.** *(a) Greater individual earnings in Market 1 are associated with increases in Joviality.*

*(b) Greater individual earnings in Market 1 are associated with decreases in Fear.*

# 4 Results

## 4.1 Manipulation check

We first consider whether our manipulation of emotions is successful. To be specific, we verify that the videos induce the intended emotions without generating other, unwanted emotions. Figure 2 displays the average changes in four related emotion indices (Fear, Joviality, Hostility, and Sadness) in each treatment after subjects watched the video.[2] We employ *t*-tests and place the 95% confidence intervals for each variable on the graph. The results show that the Fearful video significantly increased subjects' fear by 0.36 ($p < 0.001$) and did not generate a significant increase in Joviality, Hostility, or Sadness. The Happy video increased subjects' Joviality level by 0.278 ($p < 0.001$) and did not increase other emotion indicators. Subjects did not show any significant change in any of the four emotion indices in the Neutral treatment after the video. Hence, our manipulation of emotions worked as intended: The Happy treatment increased Joviality and the Fearful treatment increased Fear with no other positive effects observed.

[2] For the absolute values of the emotion indicators from Survey 1 (before video) and Survey 2 (after video) see Appendix A.

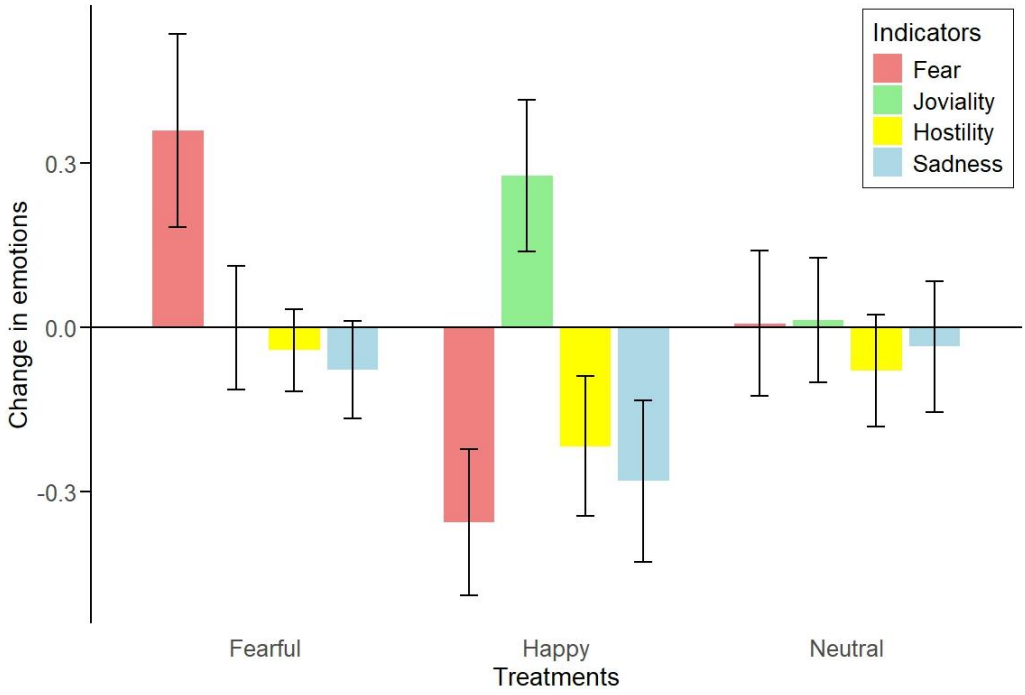



Figure 2. Manipulation check

*Note*: The bars represent the changes in the emotion indices, calculated as after-video values minus the before-video values. We then compute the average changes in each treatment. The 95% confidence intervals for the mean change are attached to each bar.

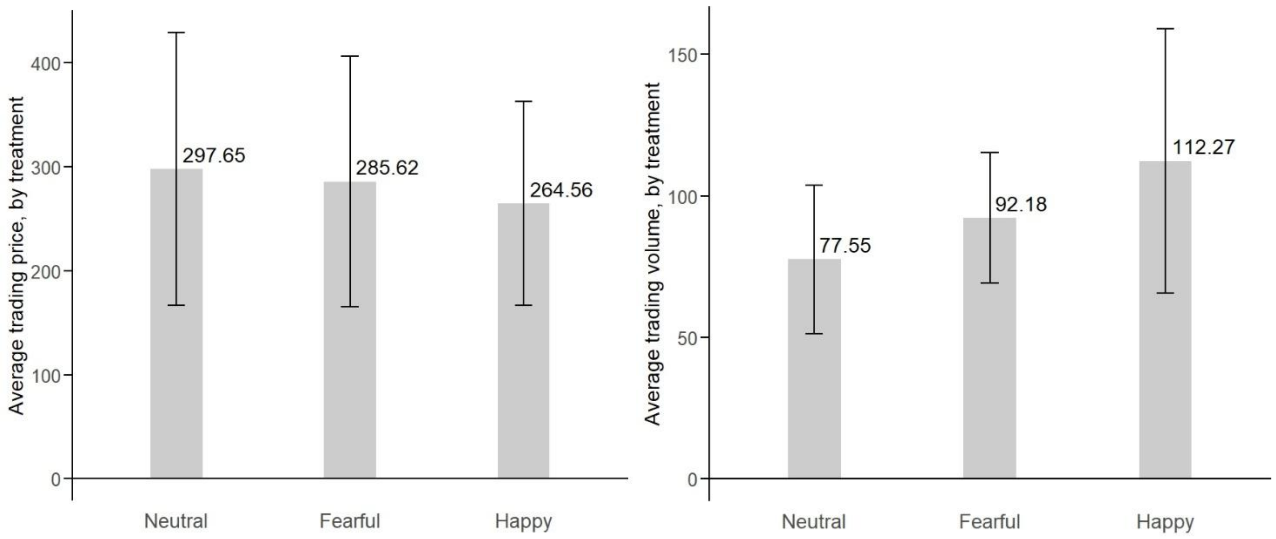
## 4.2 The effect of incidental emotions on market activity

We now consider the effect of induced emotions on transaction price.[3] In the left panel of Figure 3 we report the average price on the session level in each treatment and 95% confidence intervals for the treatment means. In all treatments, the average trading prices are far above the intrinsic value of one share, which is 92. The Neutral sessions have an average price of 297.65, followed by Fearful (285.62) and Happy (264.56). Pairwise *t*-tests indicate that prices do not significantly differ between any pair of treatments. A one-sided test of the hypothesis that the average prices in Neutral and Fear are equal yields $p = 0.456$, between Happy and Neutral yields $p = 0.645$, and between Happy and Fearful yields $p = 0.600$. Similar results are obtained by using Mann-Whitney tests (one-sided $p = 0.513$, 0.641, and 0.539, respectively) and a Jonckheere-Terpstra test to test whether the three-ordered group exhibit a trend[4] ($p =$

[3] Trading prices are the prices of the completed transactions. We do not consider the offers that are submitted but not accepted.

[4] The null hypothesis is that the average trading price in Happy is equal to the price in Neutral, which is equal to the price in Fearful. The alternative hypothesis is that the price in Happy is greater than or equal to the price in Neutral, and the price in Neutral is greater than or equal to the price in Fearful, with at least one strict inequality.

0.671 for the order Happy > Neutral > Fearful). By restricting the analysis to the first 3 minutes of each session, when the emotion induction presumably has its strongest effect, there is also no significant difference between pair of treatments (see Appendix A). Therefore, on the session level, manipulating traders' emotions does not significantly change market prices. We reject Hypothesis 1.




(a) Average price (b) Average trading volume

Figure 3. Session-level price and trading volume

*Note*: The bars in (a) represent the average trading price, calculated by averaging the prices of all transactions in each session and then taking the average across all sessions within each treatment. The bars in (b) are the average trading volume across all sessions within each treatment. The 95% confidence intervals are attached to each bar.

The emotion manipulations do not affect the tendency to trade either. The right panel of Figure 3 displays the average trading volume in each treatment. Although each market has a total stock of up to 24 shares that traders hold at any time, the number of trade is considerably higher than this level in all treatments. In the 15-minute life of the asset, each share is traded on average 3 to 5 times. While the average trading volumes differ across treatments, the volume in Happy does not significantly differ from Fearful (two-sided *t*-test, $p = 0.495$) or Neutral (two-sided *t*-test, $p = 0.222$). The trading volume in Neutral is also not significantly different from that in Fearful (two-sided *t*-test, $p = 0.418$). A Mann-Whitney test shows that the difference between the Happy and Neutral treatments is nearly significant ($p = 0.066$), but the trading volumes between Happy and Fearful do not significantly differ from each other ($p = 0.974$). The lack of a relationship between treatment and transaction volume remains robust when using

Jonckheere-Terpstra test to test for a trend across the three groups ($p$ = 0.864 with order Happy > Neutral > Fearful) or considering only the first 3 minutes of each session (see Appendix A). We thus obtain our first result:

**Result 1.** *Incidental joviality and fear do not affect market behavior, as measured by transaction price and trading volume. Hypothesis 1 is not supported.*

We now analyze how individual trader behavior correlates with their measured emotional state. The results from the OLS regressions are reported in Table 2. Standard errors are clustered at the session level to account for potential correlations in the error terms, as we observe traders' behaviors are highly correlated within a session. *Ntrade1* is the number of trades an individual makes (including selling and buying) in the first market. *Price1* is the subject's average trading price, divided by 100 to make the size of its coefficients comparable across analyses. *Share1* denotes the number of shares an individual holds at the end of the first market.

The independent variables, *Joviality1* and *Fear1* are the values of the emotion indexes on the PANAS-X survey after the video is shown but before the market opens. These variables describe the subjects' initial emotional states when they enter Market 1. The average values of *Joviality1* and *Fear1* are 2.924 and 1.577 respectively. We also include session fixed effects in some regressions where the dependent variables typically take on greatly differing average values across sessions. For more descriptive statistics of the variables used in the regressions, see Appendix A.

The results show that an individual's joviality is correlated with a higher average price for that individual's trades, although the effect is economically small (2 cents for one standard deviation change in Joviality). This is a similar directional correlation that has been observed in the prior literature. Fear does not exhibit a correlation with price level. Regressions on sub-samples of male and non-male participants show that the coefficient of *Joviality1* becomes insignificant among both males and non-males (one-sided $p$ = 0.132 and 0.277). Fearful male subjects tend to trade at higher price (one-sided $p$ = 0.015), while fearful non-male subjects trade at lower prices, but the latter effect is insignificant (one-sided $p$ = 0.133). These results do not reveal a robust pattern supporting the notion that trader fear correlates with transaction price.

Table 2. Measured emotions and market activity in Market 1

| | (1) *Price1* | (2) *Price1 (M)* | (3) *Price1 (NM)* | (4) *Ntrade1* | (5) *Ntrade1 (M)* | (6) *Ntrade1 (NM)* | (7) *Share1* | (8) *Share1 (M)* | (9) *Share1 (NM)* |
|---|---|---|---|---|---|---|---|---|---|
| *Joviality1* | 0.060** | 0.064 | 0.076 | 1.293 | 0.774 | -0.104 | 0.074 | 0.047 | 0.186 |
| | (0.033) | (0.053) | (0.127) | (0.895) | (1.417) | (2.410) | (0.234) | (0.380) | (0.369) |
| *Fear1* | 0.048 | 0.189** | -0.145 | 0.459 | 1.510 | 0.883 | -0.065 | -0.098 | 0.006 |
| | (0.050) | (0.083) | (0.128) | (1.421) | (1.985) | (2.895) | (0.262) | (0.397) | (0.359) |
| *Constant* | 0.567*** | 0.921*** | 6.823*** | 4.573 | 18.613*** | 14.937** | 2.886*** | 3.190** | 2.298* |
| | (0.149) | (0.257) | (0.298) | (5.185) | (4.709) | (6.472) | (0.910) | (1.338) | (1.229) |
| Session FE | Y | Y | Y | Y | Y | Y | N | N | N |
| $R^2$ | 0.949 | 0.978 | 0.929 | 0.524 | 0.684 | 0.579 | 0.001 | 0.000 | 0.004 |
| *N* | 246 | 119 | 103 | 247 | 119 | 104 | 247 | 119 | 104 |

*Note*: OLS regressions. Standard errors (in parentheses) are adjusted for clustering at the session level. Column (1) (4) (7) include all participants. Column (2) (5) (8) include only the male subsample. Column (3) (6) (9) use the non-male subsample. The coefficients of *Joviality1* and *Fear1* in column (1)-(3) use one-sided test to be consistent with our hypotheses. *, **, *** represent $p < 0.1$, $p < 0.05$, and $p < 0.01$ respectively.

An individual's emotional state is uncorrelated with the number of trades they make. In column (4), the coefficients of *Joviality1* and *Fear1* are insignificant ($p$ = 0.158 and 0.749, respectively), meaning that incidental emotions do not change the frequency of trade. These coefficients remain insignificant for the male (in column 5) and non-male (in column 6) subsamples. Emotions do not influence the number of shares one holds either; columns (7)-(9) show that incidental Joviality and Fear do not correlate with *Share1*.

## 4.3 The effect of market activity on emotions

To test Hypothesis 2, we investigate whether market outcomes affect subjects' emotions. Based on prior research suggesting that emotions induced by videos dissipate after a few minutes, we assume that the effects of the VR videos do not persist beyond the first 15-minute market.[5] Therefore, we apply two measures to assess the emotions generated from the market: (1) The absolute emotional state, measured

[5] This assumption is confirmed in our data. We test whether the video effects disappear by comparing the difference between the first PANAS-X survey (before video) and the third one (after market) across treatments. If the video effect dissipates, then the difference in surveys should be the same across three treatments. One-way Anova tests confirm our hypothesis: a test that the mean differences across all groups are equal yields $p$ = 0.886 for joviality, 0.142 for fear, 0.304 for hostility, and 0.600 for sadness.

by the third PANAS-X survey completed after the market close of Market 1 (*Joviality2* and *Fear2*); (2) The relative emotion change, measured by subtracting the results of the first PANAS-X survey taken before video is shown from the third one taken after Market 1 *(ΔJoviality* and *ΔFear*). The changes in emotion indicators reflect how emotions are affected by the market. The mean of *Joviality2* is 2.762, while the mean of *Fear2* is 1.507. Δ*Joviality* ranges from -2.7 to 2.34, with an average of -0.063. Δ*Fear* has a minimum of -1.8 and a maximum of 2.6, with an average of -0.082. See Appendix A for other descriptive statistics.

As independent variables characterizing market outcomes, we consider the number of trades an individual made (*Ntrade1*), the average trading price in the market, divided by 100 (*Price1*), the number of shares held by the end of the market (*Share1*), and subject's earning divided by 1,000 (*Earning1*), in Market 1. The results are shown in Table 3. While our hypotheses concern the effects of Joviality and Fear, we also report regression results on the determinants of hostility and sadness in Appendix A.

Table 3. The effect of market activity on emotions

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | *Joviality2* | *Joviality2* | *ΔJoviality* | *ΔJoviality* | *Fear2* | *Fear2* | *ΔFear* | *ΔFear* |
| *Earning1* | 0.114** | 0.112** | 0.146*** | 0.130*** | -0.106*** | -0.106** | -0.094*** | -0.096*** |
| | (0.061) | (0.061) | (0.038) | (0.038) | (0.043) | (0.042) | (0.035) | (0.035) |
| *Price1* | | 0.015 | | -0.040* | | 0.050** | | 0.016 |
| | | (0.036) | | (0.022) | | (0.024) | | (0.021) |
| *Ntrade1* | | -0.005 | | -0.005* | | 0.001 | | -0.004** |
| | | (0.003) | | (0.003) | | (0.002) | | (0.002) |
| *Share1* | | 0.016 | | -0.007 | | -0.013 | | 0.012 |
| | | (0.025) | | (0.012) | | (0.012) | | (0.011) |
| *Constant* | 2.474*** | 2.521*** | -0.432*** | -0.124 | 1.776*** | 1.655*** | 0.155 | 0.186 |
| | (0.165) | (0.249) | (0.108) | (0.160) | (0.132) | (0.154) | (0.108) | (0.144) |
| $R^2$ | 0.019 | 0.032 | 0.064 | 0.088 | 0.039 | 0.062 | 0.040 | 0.071 |
| *N* | 223 | 222 | 223 | 222 | 223 | 222 | 223 | 222 |

*Note*: OLS regressions. Robust standard errors are reported (in parentheses). The coefficients of *Earning1* use one-sided tests to be consistent with our hypotheses. *, **, *** represent $p < 0.1$, $p < 0.05$, and $p < 0.01$ respectively. *N* is smaller than the number of participants, since in three sessions a computer error caused the data from the third PANAS-X survey and demographic questionnaire to be lost. Robust standard errors are employed.

We find that market participation significantly influences emotions through individual *Earnings*. Specifically, column (1) shows that for every additional 1,000 francs earned, subjects' joviality increases

by 0.114 (one-sided $p = 0.033$). After controlling other variables regarding market activity in column (2), we obtain very similar results: Joviality increases by 0.112 (one-sided $p = 0.035$) per 1000 francs. The results are robust to using a relative measure in columns (3) and (4). Higher earnings also reduce Fear. An increase of 1,000 francs in earnings reduces fear by 0.106 in column (6) (one-sided $p = 0.006$), or by 0.096 more using the relative measure in column (8) (one-sided $p = 0.004$). All these effects are statistically significant, indicating that higher earnings in the market tend to make people happier and less fearful. The similarity of results obtained using both absolute and relative measures of emotions provides further evidence that it is the market participation that induces changes in emotions. Therefore, Hypothesis 2 is supported. Other variables describing market activity, including trading price, trading volume, and shares held, do not exhibit a systematic correlation with emotions. We also regress Price1 alone on these emotion indicators and do not find a robust pattern (see Appendix A). We conclude that:

**Result 2.** *Market outcomes affect subjects' emotions through earnings. Higher individual earnings are associated with increases in Joviality and decreases in Fear. Hypothesis 2 is supported.*

## 4.4 Integral emotions and market activity

We have shown that incidental emotions do not exert a causal effect on traders' behavior. We now consider whether emotions generated *from* the first market, integral emotions, correlate with activity in the second market. This is a correlational relation since those whose emotions are affected by the first market are not random. To explore this further, we implement Series 2 in 2024, adding one more market after the third PANAS-X survey. The survey and the market that followed enable us to examine whether emotional changes during the previous market period predict trading behavior in the next period.

The OLS regression results are reported in Table 4. Standard errors are clustered at the session level. Regarding integral emotions, as we show that the effect of the video dissipates, we use the change between the third PANAS-X survey (after-market) and the first one (before-video) to measure emotions generated from market participation. *Price2* is the subject's average transaction price in the second market, divided by 100. *Ntrade2* is the number of trades the participant made in the second market. *Share2* is the number of shares one held at the end of the second market. We control for variables describing the individual's behavior in the first market, since they depend on idiosyncratic individual trading habits. Session fixed effects are controlled in the regressions on price and trading quantity to account for heterogeneity among sessions.

Table 4. Integral emotions and market activity

| | (1) *Price2* | (2) *Price2* | (3) *Ntrade2* | (4) *Ntrade2* | (5) *Share2* | (6) *Share2* |
|---|---|---|---|---|---|---|
| *ΔJoviality* | -0.026 | -0.033 | 0.185 | 0.786 | 0.008 | 0.162 |
| | (0.052) | (0.071) | (1.040) | (1.287) | (0.241) | (0.209) |
| *ΔFear* | 0.122* | 0.124** | 3.515** | 3.258** | -0.126 | -0.182 |
| | (0.062) | (0.057) | (1.221) | (1.212) | (0.406) | (0.388) |
| *Price1* | 0.210** | 0.211** | | | | |
| | (0.085) | (0.084) | | | | |
| *Ntrade1* | | | 0.855*** | 0.840*** | | |
| | | | (0.104) | (0.100) | | |
| *Share1* | | | | | 0.542*** | 0.531*** |
| | | | | | (0.116) | (0.119) |
| *Earning1* | | 0.009 | | -0.836 | | -0.213 |
| | | (0.043) | | (0.674) | | (0.127) |
| *Constant* | 1.249*** | 1.225*** | -2.504** | -0.267 | 1.372*** | 1.969*** |
| | (0.119) | (0.162) | (0.978) | (1.971) | (0.349) | (0.460) |
| Session FE | Y | Y | Y | Y | N | N |
| $R^2$ | 0.927 | 0.927 | 0.831 | 0.834 | 0.241 | 0.250 |
| *N* | 110 | 110 | 112 | 112 | 112 | 112 |

*Note*: OLS regressions. Standard errors (in parentheses) are adjusted for clustering at the session level. The coefficients of *ΔJoviality* and *ΔFear* in column (1)-(2) are subject to two-sided tests. *, **, *** represent $p < 0.1$, $p < 0.05$, and $p < 0.01$ respectively. Only Series 2 data is used. Column (1)-(2) have a smaller sample size because some subjects did not sell or buy.

The results show that the change in Joviality in the first market does not correlate with transaction price (one-sided $p = 0.69$ in column (1) and 0.675 in column (2), respectively). This is the case regardless of whether or not *Earning1*, which we have established influences emotional state, is included. However, Fear generated from the market is correlated with higher trading prices as indicated in column (1) and (2). Subjects whose Fear increases in Market 1 by one unit more on average trade at 21 francs higher in Market 2. The results differ from Table 2, where incidental fear is uncorrelated with price.

*ΔJoviality* does not correlate with the number of trades ($p = 0.431$), but fearful subjects tend to trade more actively. In column (3), when fear index increases by 1 more, subjects make 3.515 more trades on

average ($p$ = 0.006). As Section 4.3 demonstrates that emotions are partially driven by earnings – lower earnings are correlated with greater increases in fear, omitting previous earnings might overestimate the true effect of emotions on trade. Column (4) adds *Earning1* into the regression, and the coefficient of *Fear2* becomes smaller but remains significant ($p$ = 0.009). This is evidence against the notion that fear causes lower prices and reduced market participation, since the correlation we observe is in the opposite direction.

# 5 Discussion

The notion that the emotional state of market participants is correlated with market prices is deeply held and supported with empirical evidence. A number of studies find a relationship between events that affect aggregate mood and stock returns, and trader mood is thought to be the mediator of the relationship. However, the financial, economic, or psychological foundation for a causal relationship whereby positive emotions on the part of traders *cause* market prices to be higher or fear *causes* prices to be lower is not clear. In this study, we use the laboratory to randomly assign individuals drawn from the same population into different emotional states. Groups of traders in different emotional states then participate in markets with an identical structure, so that the causal effect of emotions can be directly compared. We detect no relationship between the emotional state of traders at the open of a market and subsequent prices.

On the other hand, we find a strong relationship between market outcomes and emotional state. Higher earnings result in an increase in Joviality and a decrease in Fear. In the field, higher prices and earnings go hand in hand, since most investors have long positions and earn more when prices increase. However, in our experiment, in which average earnings depend only on the final dividend instead of prices, the price level has no effect on emotional state. This suggests that market euphoria in the field is a consequence of traders making strong earnings rather than of high prices. Fear on the market stems from traders responding to losing money rather than to low prices per se.

We conclude with some thoughts on distinguishing emotions from beliefs about the future prospects of an investment. The teem sentiment is widely used in finance to refer to beliefs about future returns. Optimism about an asset is a property of beliefs about future asset prices, not of an emotional state. These sentiments are not emotions, as they are understood in psychology. More optimistic beliefs would presumably lead to demand for the asset and thus an increase in prices. Outcomes of events such as

sporting matches and weather conditions may influence beliefs about the real economy and these beliefs lead to higher asset prices, as individuals are more likely to go out for shopping and entertainment when the weather has been good or when a home team has won a big game. The optimistic beliefs may cause a positive emotional state on the part of those holding the asset, as their positions are viewed as more profitable. As prices of the asset increase, positive emotions are also experienced by those holding the asset or those purchasing the asset because of the upward trend in prices. Fear operates in a similar manner when beliefs are pessimistic. This results in a correlation between prices and traders' emotional states. However, we believe that trader emotions are not causing the price changes, but rather are consequences of the price changes. The correlations may also be caused by third variables, such as beliefs about future valuations, affecting both asset prices and emotions, though our experiment is not designed to establish this.

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# A Supplemental tables and figures

Table A1. Average values of emotion indices before and after the video is shown

| | | Joviality | Fear | Hostility | Sadness |
|---|---|---|---|---|---|
| Fearful | Before | 2.895 | 1.566 | 1.423 | 1.568 |
| | After | 2.895 | 1.926*** | 1.382 | 1.491* |
| Happy | Before | 2.790 | 1.688 | 1.418 | 1.619 |
| | After | 3.068*** | 1.332*** | 1.201*** | 1.338*** |
| Neutral | Before | 2.793 | 1.450 | 1.363 | 1.459 |
| | After | 2.807 | 1.458 | 1.284 | 1.425 |

Table A2. Descriptive statistics of market variables

| Variable | Obs. | Mean | Std. dev. | Min | Max | 25%p | 75%p |
|---|---|---|---|---|---|---|---|
| *Ntrade1* | 247 | 25.117 | 19.879 | 0 | 120 | 13 | 31 |
| *Ntrade2* | 112 | 21.607 | 21.641 | 0 | 112 | 7 | 104 |
| *Price1* | 246 | 2.844 | 1.944 | 0 | 8.750 | 1.464 | 3.713 |
| *Price2* | 110 | 2.655 | 1.531 | 0.14 | 6.87 | 1.492 | 4.070 |
| *Share1* | 247 | 3 | 3.503 | 0 | 19 | 0 | 5 |
| *Share2* | 112 | 3 | 3.216 | 0 | 18 | 0 | 5 |
| *Earning1* | 247 | 2.549 | 1.236 | 0.02 | 7.419 | 1.876 | 3.2 |
| *Joviality1* | 247 | 2.924 | 1.059 | 1 | 5 | 2.1 | 3.667 |
| *Joviality2* | 223 | 2.762 | 1.065 | 1 | 5 | 2 | 3.5 |
| *ΔJoviality* | 223 | -0.063 | 0.739 | -2.7 | 2.34 | -0.5 | 0.333 |
| *Fear1* | 247 | 1.577 | 0.718 | 1 | 4 | 1 | 2 |
| *Fear2* | 223 | 1.507 | 0.689 | 1 | 4.6 | 1 | 1.8 |
| *ΔFear* | 223 | -0.082 | 0.597 | -1.8 | 2.6 | -0.4 | 0.2 |
| *Hostility2* | 223 | 1.547 | 0.827 | 1 | 7.75 | 1 | 1.75 |
| *ΔHostility* | 223 | 0.142 | 0.785 | -2.75 | 6.75 | 0 | 0.25 |
| *Sadness2* | 223 | 1.515 | 0.691 | 1 | 4.25 | 1 | 1.75 |
| *ΔSadness* | 223 | -0.053 | 0.671 | -3.5 | 2.75 | -0.75 | 0.25 |

Ntrade is the number of units traded, Price is the average transaction price in a Market. Share is the number of units held at the end of the market. Earnings are the sum of the number of units held at the end of the market times the dividend realization of the asset plus bet capital gains from trading during the Market. 1 indicates emotion index measured before Market 1. 2 indicates emotion index measured after Market 1. Δ is a change in the value of the index from before to after Market 1. See Appendix B for calculation of emotion indices.

Table A3. The effect of trading price on Joviality and Fear

| | (1) *Joviality2* | (2) *ΔJoviality* | (3) *Fear2* | (4) *ΔFear* |
|---|---|---|---|---|
| *Price1* | 0.023 | -0.034 | 0.052** | 0.030 |
| | (0.035) | (0.023) | (0.024) | (0.022) |
| *Constant* | 2.696*** | 0.042 | 1.354*** | -0.173*** |
| | (0.132) | (0.093) | (0.078) | (0.065) |
| $R^2$ | 0.002 | 0.008 | 0.022 | 0.010 |
| *N* | 222 | 222 | 222 | 222 |

*Note*: OLS regressions. Robust standard errors are reported (in parentheses). *, **, *** represent $p < 0.1$, $p < 0.05$, and $p < 0.01$ respectively.

Table A4. The effect of market activity on Hostility and Sadness

| | (1) *Hostility2* | (2) *Hostility2* | (3) *ΔHostility* | (4) *ΔHostility* | (5) *Sadness2* | (6) *Sadness2* | (7) *ΔSadness* | (8) *ΔSadness* |
|---|---|---|---|---|---|---|---|---|
| *Earning1* | -0.117*** | -0.122*** | -0.076** | -0.082*** | -0.110*** | -0.116*** | -0.049 | -0.051 |
| | (0.037) | (0.036) | (0.029) | (0.028) | (0.037) | (0.037) | (0.038) | (0.039) |
| *Price1* | | 0.001 | | -0.001 | | -0.000 | | -0.001 |
| | | (0.003) | | (0.003) | | (0.002) | | (0.002) |
| *Ntrade1* | | 0.025 | | -0.015 | | 0.009 | | -0.016 |
| | | (0.025) | | (0.025) | | (0.026) | | (0.022) |
| *Share1* | | -0.024* | | -0.010 | | -0.019 | | 0.006 |
| | | (0.014) | | (0.016) | | (0.012) | | (0.011) |
| *Constant* | 1.845*** | 1.822*** | 0.334*** | 0.443*** | 1.792*** | 1.847*** | 0.071 | 0.140 |
| | (0.112) | (0.171) | (0.091) | (0.158) | (0.114) | (0.153) | (0.113) | (0.156) |
| $R^2$ | 0.033 | 0.046 | 0.015 | 0.018 | 0.041 | 0.050 | 0.009 | 0.012 |
| *N* | 223 | 222 | 223 | 222 | 223 | 222 | 223 | 222 |

*Note*: OLS regressions. Robust standard errors are reported (in parentheses). *, **, *** represent $p < 0.1$, $p < 0.05$, and $p < 0.01$ respectively.

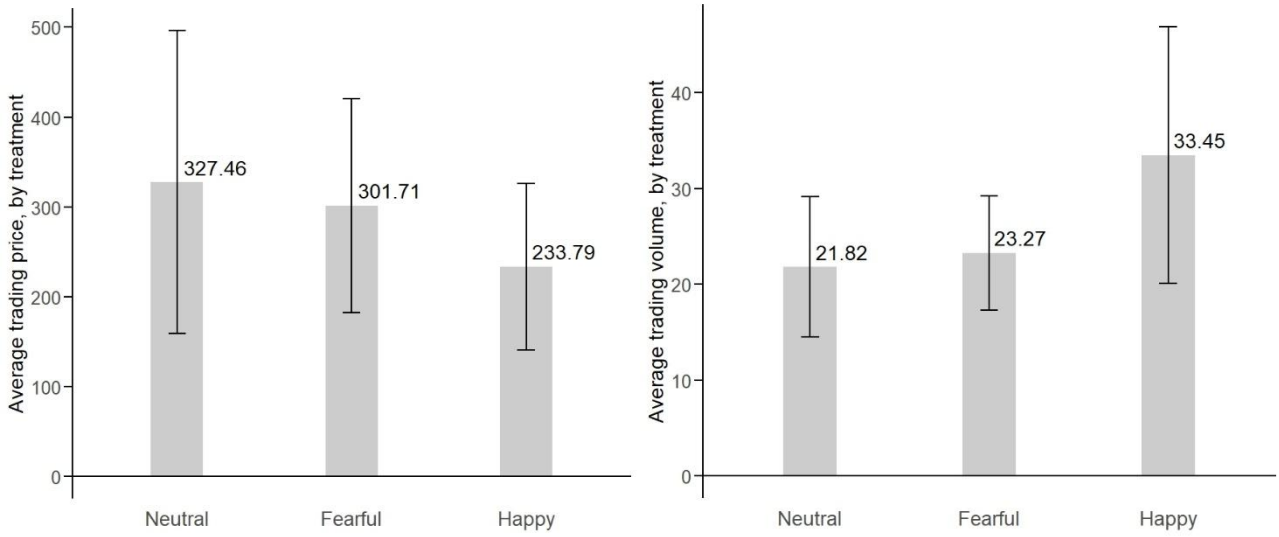



Figure A1. Price and trading volume, first 3 minutes, all treatments

# B Instructions and forms used in the experiment

## B1: Instructions for the experiment

### 1. General Instructions

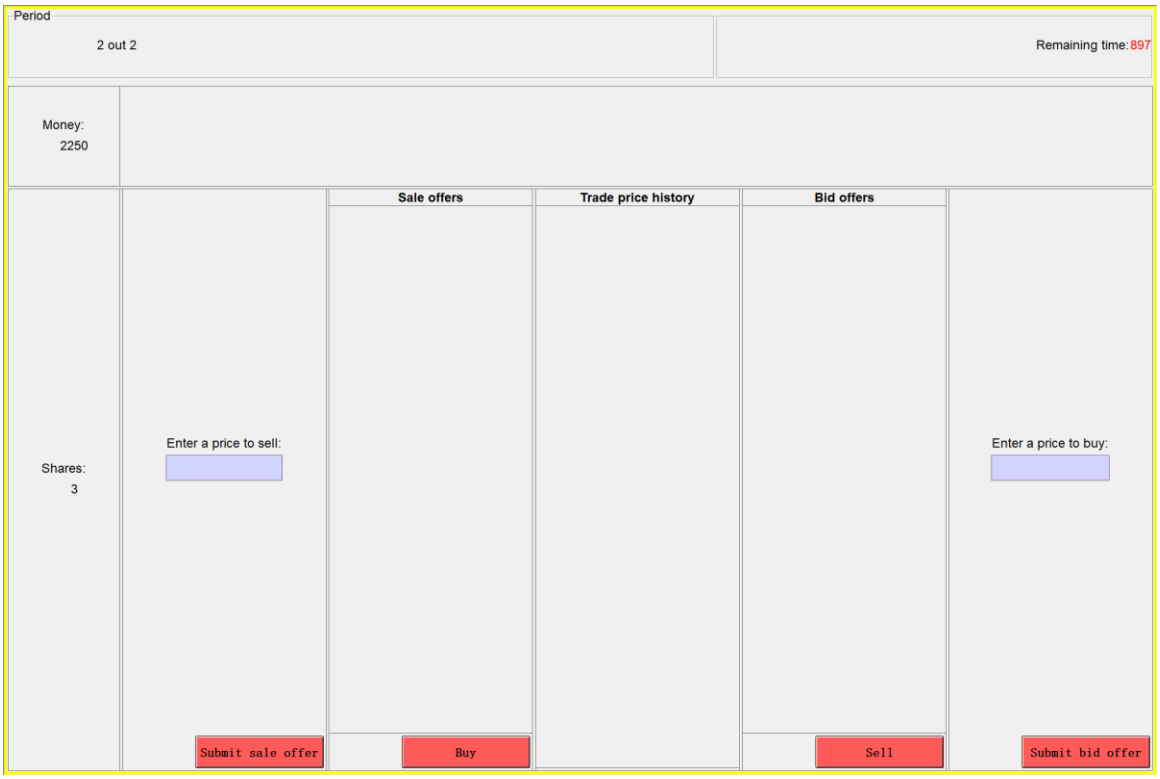
This is an experiment on market decision making. If you follow the instructions carefully, you might earn a considerable amount of money, which will be paid to you in cash at the end of the experiment.

From now on until the end of the experiment, please do not communicate with other participants or use your own electronic devices. Violation of these rules will lead to the exclusion from the study and all payments. If you have any questions, please raise your hand, and I will come to your table to answer your questions in private.

There are **…. participants** in this experiment. All of them are **Traders**. The experiment will consist of **two trading periods**. During each period, you can buy and sell in a market. The currency used in the market is francs, which will be converted into US dollars at an exchange rate of **300 francs for one dollar.**

You will receive **5 dollars** for showing up on time for this study. Your total earnings would be your earnings from the markets, plus your show-up fee.

### 2. How to use the computerized market




During the trading period, you will see a computer screen like the one shown above. You can use the interface to buy and sell **Shares**. On the top left corner of your screen, you see the **remaining money** you have. On the left-most column, you see the **number of shares** you currently hold.

**Selling in the market**

If you would like to sell a share, you may use the **"Enter a price to sell"** column (the second column). Enter the price at which you are offering to sell one share, then click **"Submit sale offer"** at the bottom of the column. Your sale price will appear immediately in the third column, entitled **"Sale offers"**.

Note: You can make multiple sale offers. However, if one of your sale offers is accepted, *all other* sale offers from you would disappear.

You can also accept a bid offer to sell a share. Check the **"Bid offers"** column (the second-to-last column). This column displays all the prices from those who want to *buy* a share at. The highest bid price will always be on the bottom of that list and will be highlighted. If you click **"Sell"** at the bottom of this column, you will sell one share for the highest current bid price.

**Buying in the market**

If you would like to offer to buy a share, you may use the **"Enter a price to buy"** column (the last column). Enter the price at which you are offering to buy one share, then click **"Submit bid offer"** at the bottom of the column. Your bid price will appear immediately in the second-to-last column, entitled **"Bid offers"**.

Note: You can make multiple bid offers. However, if one of your bid offers is accepted, *all other* bid offers from you would disappear.

You can also accept a sale offer to buy a share. Check the **"Sale offers"** column (the third column). This column displays all the prices from those who want to *sell* a share at. The lowest sale price will always be on the bottom of that list and will be highlighted. If you click **"Buy"** at the button of this column, you will buy one share for the lowest current sale price.

When you buy a share, your money decreases by the price of the purchase, and the number of shares you own increases by one. When you sell a share, your money increases by the price of the sale, and the number of shares you own decreases by one.

### 3. The shares traded in the market

There will be **2 trading periods**. Each period lasts **15 minutes**. During each period, there will be a market open, operating under the rules described previously, in which you are permitted to buy and sell shares. Every trader is endowed with **3 shares AND 2250 francs** at the beginning of a period.

You receive **dividend** for each share you have at the end of the period. At the end of a trading period, **every share you hold will pay you a dividend of 20, 44, 104, 200 francs, each with equal chance**. The computer will roll a 4-sided die to decide your dividend. The dividends are added to your money balance automatically after the period. After the dividend is paid, the market is closed, and the period ends.

### 4. Your Earnings

Your earnings in one period will equal the total amount of money you have at the end of the period, *after* the dividend has been paid. In other words,

The earnings you will receive = The money you had at the beginning of the period

+ the dividends you received

+ the money you received from sales of shares

- the money you spent on purchases of shares

Your total earnings will be the **sum** of your earnings in the two periods, plus your show-up fee.

## Practice Period

Before the formal periods start, we provide a practice period for you to get familiar with the computerized market. The practice period lasts 10 minutes. Try to bid and sell as many times as possible. **The practice period does not count for payment.** If you have any questions, please raise your hand.

## B.2. The PANAS-X survey used to measure emotional state

### Survey

The survey below consists of several words and phrases that describe different feelings and emotions. Read each item, then **indicate to what extent you feel this way right now** by choosing the appropriate answer on the right-hand side to that word**.** Use the following scale to record your answers:

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Very slightly | A little | Moderately | Quite a bit | Extremely |

| | | | | |
|---|---|---|---|---|
| Afraid ___ | Angry ___ | Shaky ___ | Nervous ___ | Attentive ___ |
| Calm ___ | Determined___ | Alert ___ | Excited ___ | Concentrating |
| Frightened ___ | Irritable ___ | Downhearted ___ | Enthusiastic ___ | Hostile ___ |
| Cheerful ___ | Disgusted ___ | Happy ___ | Energetic ___ | Scared ___ |
| Lonely ___ | Joyful ___ | Sad ___ | Alone___ | Relaxed ___ |

Notes: The four indices were calculated in the following manner:

Joviality = (Cheerful + Joyful + Happy + Excited + Enthusiastic + Energetic)/6

Fear = (Afraid + Frightened + Shaky + Nervous + Scared)/5

Sadness = (Lonely + Downhearted + Sad + Alone)/4

Hostility = (Angry + Irritable + Disgusted + Hostile)/4

### B.3. VR headset instructions

Now, the experimenter is going to bring a VR headset to your desk. There will be a 3-minute video which you are required to watch. After receiving the equipment, please just wear the headset and leave the handle on the desk for now. DO NOT PRESS ANY BUTTON UNTIL INSTRUCTED.

Tip: If you wear glasses, try to put your glasses into the headset *before* wearing the headset.

Use your right hand to hold the handle. There will be a curve pointing from your handle to the front, you can imagine the endpoint of the curve as your mouse pointer. To play the video, target the endpoint of the curve on the "play" button in the middle, then press the button on your handle **below your forefinger**. This is also the only button you need to use in this experiment.

Please stand up when you watch the video. After the video is over, you can sit down and take off the headset, then click on the "OK" button on the computer to proceed. If you have any questions, please raise your hand.

Now, you can go ahead and play the video.

### B.4. Additional instructions before the market in the second series of sessions

Now, you are going to participate in the formal trading periods. As a reminder, there will be 2 trading periods. Each period lasts 15 minutes. During each period, there will be a market open, in which you can buy and sell shares. Every trader is endowed with 3 shares AND 2250 francs. At the end of a trading period, every share you hold will pay you a dividend of 20, 44, 104, 200 francs, each with equal chance. The dividends will be added to your money balance automatically.

Your earnings in one period will equal the amount of money you have at the end of the period, after the dividends have been paid. Your total earnings will be the sum of your earnings in the two periods, plus your show-up fee.