

# Bubbling with Excitement: An Experiment\*

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## Abstract

Anecdotal and indirect empirical evidence suggest that excitement and market bubbles are intertwined, such that excitement not only arises during bubbles but may also help fuel them. We directly test the impact of excitement on bubbles in a bubble-prone experimental asset-pricing market (Capinalp, Porter, and Smith, 2001). Prior to trading, participants are assigned to emotion inductions through video clips. The results of fifty-five markets show larger asset pricing bubbles in magnitude and amplitude in the *excitement* treatment relative to a treatment of same valence and lower intensity (*calm*) and a treatment of similar intensity and opposite valence (*fear*).

**JEL classification:** G02, C91

## 1. Introduction

From “tulipmania” of 1637 to the “irrational exuberance” of the late 1990s, popular accounts emphasize the role of emotions, and excitement in particular, on investment bubbles. However, there is no direct evidence in the literature demonstrating the causal impact of this pleasantly intense emotion on asset-pricing bubbles.

During the run-up of a bubble, an investor who is earning unusually and unexpectedly large returns is likely to experience excitement. This excitement may trigger excitement in others (Parkinson and Simons, 2009). Excitement and other emotions influence behavior directly and also through their impact on judgments of expected consequences (Lowenstein and Lerner, 2003). Furthermore, “as emotions intensify, they exert an ever-increasing influence on behavior” (Lowenstein and Lerner, 2003).

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We posit that excitement changes behavior in such a way as to magnify the size of asset pricing bubbles. We test this conjecture in a bubble-prone experimental market setting (Capinalp, Porter, and Smith, 2001). While we also believe that real world bubbles can generate excitement, we do not test this. Nor do we claim that excitement alone can generate bubbles.

While the histories of asset pricing bubbles suggest that investors become excited during bubbles, it is difficult to make causal inferences about the role of emotions in bubbles from field data. And, somewhat surprising, the majority of experimental studies of asset pricing bubbles have focused on non-emotional factors such as liquidity, experience, transparency, novelty of environment, and speculation (Capinalp, Porter, and Smith, 2001; Lei, Noussair, and Plott, 2001; Dufwenberg, Lindqvist, and Moore, 2005; Hussam, Porter, and Smith, 2008). This article reports results from laboratory financial market experiments designed to induce and, hence, directly test the impact of, this pleasantly intense emotion on asset-pricing bubbles.

In a series of experimental markets, we induce participants' incidental emotional states with video clips, a standard procedure (Rottenberg, Ray, and Gross, 2007) that is known to impact financial and economic decision-making (Andrade and Ariely, 2009; Guiso, Sapienza, and Zingales, 2013). After the incidental emotion induction, participants take part in a financial market simulation previously shown to generate bubbles. Bubbles in the "excitement" treatment are measured and compared with bubbles in two other treatments. These two additional treatments vary in either valence or intensity: a high-intensity, negative-valence treatment (i.e., "fear") and a low-intensity, positive-valence treatment (i.e., "calm").

As expected and consistent with Capinalp, Porter, and Smith's (2001) results, we observe bubbles across all three emotion treatments. Also, our calm treatment bears similar magnitude and peak amplitude to those of Capinalp *et al.* However, significant differences are observed across treatments. Our results show first and foremost that excitement produces larger asset-pricing bubbles in experimental markets when compared with both the fear and the calm treatments. The differences in the magnitudes and peak amplitudes of the bubbles are both large and statistically significant. Further, in the excitement treatment bubbles begin to form in the first round of trading while in the calm and fear treatments they do not. However, the high-intensity treatments—that is, fear and excitement—share some commonalities. Subsequent to the first round of trading, bubbles grow as much in the fear treatment as in the excitement treatment and significantly more so than in the calm treatment. That is, in these bubble-prone markets, while the fear treatment initially suppresses bubble formation, the suppression is short lived.

The rest of this article is organized as follows. In the next section, we discuss related research. We describe our experimental design in Section 2. We present results in Section 3, followed by concluding remarks.

## 2. Related Research

Bubbles in experimental asset markets were first documented by Smith, Suchanek, and Williams (1988). Subsequent studies have documented that bubbles are greater when traders are endowed with more cash relative to risky assets, when dividends are paid after each round of trading rather than at the end of trading, and when traders can buy on margin

(Capinalp, Porter, and Smith, 2001). Bubbles may be dampened or eliminated when short selling is allowed, though this is not the case for all experimental designs (King *et al.*, 1993; Haruvy and Noussair, 2006; Ackert *et al.*, 2006). Bubbles are smaller when traders are asymmetrically informed about future dividends (Sutter, Huber, and Kirchler, 2012). Bubbles are greater when the distribution of dividends is more lottery-like (Ackert *et al.*, 2006), but can arise even when dividends are non-stochastic (Porter and Smith, 1995). Bubbles are dampened or eliminated when some or all traders are experienced (Dufwenberg, Lindqvist, and Moore, 2005); however, even experienced traders may generate bubbles when market parameters change (Hussam, Porter, and Smith, 2008). Bubbles in one experimental asset may engender bubbles of similar magnitude in simultaneously traded assets (Fisher and Kelly, 2000).

One explanation as to why traders in experimental markets buy at above fundamental value is that they expect to be able to sell the asset at a yet higher price. However, Lei, Noussair, and Plott (2001) find that bubbles can arise in markets in which buyers cannot resell and, thus, speculation is not feasible. Schoenberg and Haruvy (2010) find greater bubbles when traders are given periodic performance information about the best performing trader. Kirchler, Huber, and Stöckl (2012) argue that bubbles arise in markets where the asset has a declining fundamental value because traders do not fully understand the process. Noussair, Robin, and Ruffieux (2001) generate bubbles in markets with constant fundamental values.

An emotional account suggests that intense pleasant emotions arise in bullish markets, which can in turn sustain and inflate a bubble, forming a feedback loop. Empirical evidence indeed indicates an increase in pleasantness (unpleasantness) as investors make (lose) money (Lo, Repin, and Steenbarger, 2005). Further, proxies of emotional/mood states (e.g., the weather) have shown to correlate with stock market prices. Hirshleifer and Shumway (2003) demonstrate that sunshine is correlated with stock returns. Kamstra, Kramer, and Levi (2003) show that stock returns are lower when daylight is decreasing. Bassi, Colacito, and Fulghieri (2012) provide experimental evidence that sunshine promotes risk taking, possibly mediated by sunshine's effect on mood.

Positive affect (Isen and Patrick 1983) and excitement in particular (Kuhnen and Knutson 2011) have shown to increase risk taking, whereas negative affect, particularly fear and anxiety, have shown to increase risk aversion (Kuhnen and Knutson, 2011; Lee and Andrade, 2011; Guiso, Sapienza, and Zingales, 2013). None of these findings, however, directly test whether emotions can inflate or dampen a bubble. Lahav and Meer (2010) induce positive and neutral mood prior to experimental markets to assess its impact on bubbles. Unfortunately, given the reduced sample size per treatment ( $n=2$ ), any statistical inference from that study is rather limited.

Valence and intensity represent the dominant dimensions of an emotion experience (Lang *et al.*, 1993; Barrett and Russell, 1999; Barrett 2006), and excitement is characterized by a pleasantly intense emotional state (Russell 1980). In this article, we test whether excitement, a pleasantly intense emotion likely to arise during a financial bubble, may sustain or inflate a bubble relative to two alternative treatments: one of similar intensity but of negative valence (i.e., fear) and one of similar valence but of much lower intensity (i.e., calm). Thus, our alternative emotional treatments represent the “flip-sides” of excitement in either intensity or valence (Russell 1980). We manipulate participants' emotions prior to the beginning of an experimental market and assess the impact of the induced emotion treatment on the asset-pricing market.

### 3. Experimental Design

Four hundred ninety five participants were recruited from UC Berkeley's Xlab student subject pool. No participant took part in more than one experiment. Participants were paid a \$5 show-up fee and an additional performance-based fee averaging \$21.68.

Our experimental market is modeled on those of [Smith, Suchanek, and Williams \(1988\)](#) and [Capinalp, Porter, and Smith \(2001\)](#). A security with a finite life of fifteen rounds is traded in a continuous double auction. After each round of trading the asset pays a random dividend drawn from a uniform distribution with four potential outcomes of 0, 8, 28, and 60 cents.<sup>1</sup> Thus, the expected dividend in each round is 24 cents and the fundamental value of the asset—i.e., the expected value of remaining dividends—is \$3.60 prior to the first round of trading and declines by 24 cents each round. At the end of fifteen rounds of trading the asset expires worthless. The distribution of dividends is known to all traders and the current fundamental value of the asset is displayed on each trader's computer screen. Traders also see all currently posted offers to buy and to sell. Our initial endowments, dividend distribution policy, and open order book match those used by [Capinalp, Porter, and Smith \(2001\)](#) in their treatment designed to maximize bubbles (See Appendix A).

Nine participants trade in each market; no participant traded in more than one market. Three traders receive an initial endowment of \$18.00 plus 1 share of the risky asset; three traders receive \$14.40 plus 2 shares; three traders receive \$10.80 plus 3 shares. After completing three practice rounds of trading, participants are asked to watch a video lasting approximately 5 min while the experimenter prepares for the actual experiment. Participants are told, "Because the waiting is a bit long, we will play a video clip. Since we intend to use video clips in another experiment, we've selected a few different video clips. After you've finished watching the clip, please answer a few questions about it. Note that the video is not related to your earnings today. So thank you in advance for helping out." After watching the video clip, participants answer two short questions about their emotional state and about the main purpose of the study. They then begin the trading sessions.<sup>2</sup>

To test whether excitement will produce larger bubbles relative to the other two emotion treatments, each experimental market is preceded by a video clip meant to induce a given emotional state. We ran series of fifty-five experimental markets (nine per market) distributed as follows: twenty-four excitement, fifteen calm, and sixteen fear treatments.<sup>3</sup> For the sake of robustness and to avoid the potential idiosyncrasies of each clip video, two

1 To facilitate comparisons across experimental markets, one random dividend sequence (8, 60, 28, 8, 60, 8, 0, 28, 0, 60, 28, 60, 0, 8, 8) was drawn for the first market and then used for all subsequent markets.

2 In a post-experiment survey, only 2.2% of participants correctly guessed the intended purpose of the experiment.

3 We ran twenty-four excitement treatment markets before completing all the calm and fear treatment markets. Because of the high cost of the experiments we decided to run only sixteen calm and sixteen fear treatment markets. However, we were unable to run the 16th calm treatment market because it was scheduled at end of a semester and not enough participants were available for the experiment. We also ran eight extra markets preceded by a mix of two sad video clips. Given the small sample size of this "sad" treatment and for the sake of simplicity, we have excluded them from the main analyses. The inclusion of this condition does not change in any way the main conclusions of the paper. The *sad* treatment produced bubbles between the *calm* and *fear* treatments and significantly lower than the *excitement* treatment in both magnitude and peak amplitude.

different video clips were used for each emotion treatment (excitement: *Knight & Day* and *Mr. & Mrs. Smith*; fear: *Hostel* and *Salem's Lot*; calm: *Franklin* and *Peace in the Water*).

#### 4. Emotion Induction Check

To assess the extent to which the video clips varied in valence, intensity, and emotion type as expected, we conducted an independent test of the emotion inductions. One hundred eighty five participants were recruited in an online platform (Amazon Mechanical Turk) and randomly assigned to one of the video clips. They were paid \$1 each for their participation in this study. After watching the video clip, participants reported their emotional reactions on an adapted version of the Self-Assessment Manikin (SAM), a two-item scale widely used to measure the valence and intensity of emotional reactions to stimuli (Bradley and Lang, 1994). They were then asked to indicate the type of emotion experience that best captured what they were feeling (“The movie clip made me feel ... \_\_Afraid/Scared/Anxious, \_\_Excited/Eager/Enthusiastic, \_\_Calm/Relaxed/Peaceful, \_\_” etc.; see Appendix B).

Table 1 Panels A and B report the statistical differences between the excitement treatments and the calm and fear treatments on valence and intensity, respectively. Panel C displays the distribution of emotion types per video clip.<sup>4</sup> The results show, as expected, that the video clips triggered emotional reactions of different valence and intensity. Participants indicated that both *Knight and Day* and *Mr. & Mrs. Smith* triggered positive (Panel A) and relatively intense (Panel B) emotional reactions. Also, “excited/eager/enthusiastic” was the most cited emotional reaction to those two video clips (Panel C). *Franklin and Peace in the Water* also triggered positive emotional reactions; they were, however, much lower in intensity when compared with the excitement video clips. Consistently, “calm/relaxed/peaceful” was the most cited emotional reaction. Finally, *Hostel* and *Salem's Lot* were at least as intense as the excitement videos, but were also clearly negative experiences. Further, “afraid/scared/anxious” represented the most cited emotional reactions.

#### 5. Results

Our underlying motivation is the hypothesis that, once started, real-world bubbles generate excitement and that excitement further inflates and sustains the bubble. We do not claim that excitement alone creates bubbles. To better match our experiment to our motivation, we choose experimental market conditions that have been previously shown to generate bubbles. As expected, we observe bubbles across all three emotion treatments. This is consistent with Capinap, Porter, and Smith (2001) results when they used the same endowments, dividend distribution policy, and order-book transparency that we use. Of importance, the bubbles vary as a function of the emotion treatment induced prior to the asset-pricing market (see Figure 1).

To compare the effects of excitement, fear, and calm treatments on bubbles we analyze two metrics of asset pricing bubbles, magnitude, and peak amplitude:

1. *Magnitude* measures the average difference in the price of the risky asset and its fundamental value across the fifteen rounds of trading. *Magnitude* is calculated as

4 The significance levels reported in the table are from two-tailed *t*-tests. *p*-Values are similar for rank-sum tests.

**Table 1.** Magnitude and amplitude of bubbles

Panel A reports the magnitude of bubbles across market experiments by treatment:  $Magnitude = \frac{1}{15} \sum_{r=1}^{15} (\bar{P}_r - f_r)$ , where  $\bar{P}_r$  is the average transaction price in trading round  $r$  and  $f_r$  is the fundamental value (i.e., the expected value of remaining dividends) in trading round  $r$ . Panel B reports the peak amplitude of bubbles across market experiments by treatment:  $PeakAmplitude = \max_{r \in (1,15)} \{\bar{P}_r - f_r\}$ . Panel C reports the amplitude of bubbles in Round 1 across market experiments by treatment:  $Round\ 1\ Amplitude = \bar{P}_1 - f_1$ . Panel D reports (Peak Amplitude–Round 1 Amplitude) across market experiments by treatment: (Peak Amplitude–Round 1 Amplitude).

## Panel A: Magnitude by treatment

Treatment	N	Mean	SE
Excitement	24	292.0	17.1
Calm	15	163.3	12.9
Fear	16	218.2	25.3

## Panel B: Peak Amplitude by treatment

Excitement	24	512.3	30.2
Calm	15	332.3	27.0
Fear	16	414.7	37.1

## Panel C: Round 1 Amplitude by treatment

Excitement	24	72.0	18.9
Calm	15	10.9	15.1
Fear	16	4.0	26.8

## Panel D: Peak Amplitude–Round 1 Amplitude by treatment

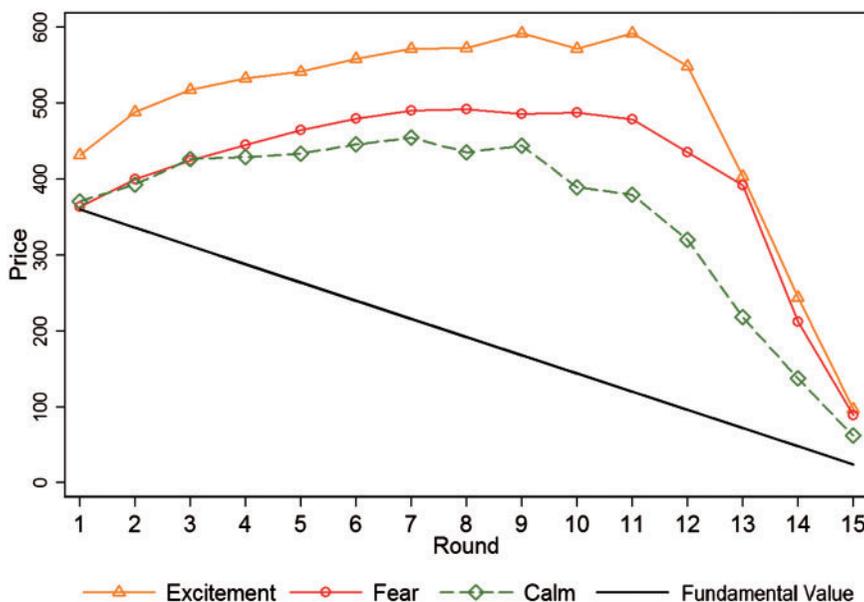
Excitement	24	440.3	33.5
Calm	15	321.4	30.3
Fear	16	410.7	25.8

$Magnitude = \frac{1}{15} \sum_{r=1}^{15} (\bar{P}_r - f_r)$  where  $\bar{P}_r$  is the average volume weighted transaction price in trading round  $r$  and  $f_r$  is the fundamental value (i.e., the expected value of remaining dividends) in trading round  $r$ .<sup>5</sup>

2. *Peak amplitude* measures the maximum difference in the price of the risky asset and its fundamental value across the fifteen rounds of trading. *Peak amplitude* is calculated as  $Peak\ Amplitude = \max_{r \in (1,15)} \{\bar{P}_r - f_r\}$ ; where  $\bar{P}_r$  is the average volume weighted transaction price in trading round  $r$ , and  $f_r$  is the fundamental value (i.e., the expected value of remaining dividends) in trading round  $r$ .<sup>6</sup>

5 Since the average fundamental value in each experiment is the same, regardless of treatment, our magnitude measure is equivalent to the relative deviation (RD) measure of bubbles in experimental markets proposed by [Stöckl, Huber, and Kirchler \(2010\)](#) and can be converted to RD by dividing by 192.

6 Some authors calculate a trough-to-peak amplitude measure that subtracts the minimum difference of price and fundamental value from the maximum difference (e.g., [Porter and Smith, 1995](#);



**Figure 1.** Average prices by round for each treatment (excitement, fear, and calm). The average trading prices are plotted round-by-round for twenty-four “Excitement” markets, sixteen “Fear” markets and fifteen “Calm” markets. The downward sloping straight line plots the declining fundamental values over fifteen rounds of trading.

Table 2, Panel A reports the average magnitude of bubbles across markets by emotion treatment. The average magnitude of the bubbles after participants are induced to feel excited (292.0) is much greater than the average magnitude of bubbles after the participants are induced to feel calm (163.3) or fear (218.2). We formally test for differences in magnitude and amplitude of bubbles under our treatments, with a two-sample two-tailed *t*-test with equal variances and with a two-sample Wilcoxon rank-sum (Mann-Whitney) test. For both tests, the magnitude of bubbles under the excitement condition is greater than that under the other two treatments. We reject the null hypothesis magnitude (excitement) = magnitude (calm) with  $t = 5.38, p < 0.001$  (*t*-test) and  $z = 4.22, p < 0.001$  (rank sum test). We reject the null hypothesis magnitude (excitement) = magnitude (fear) with  $t = 2.51, p < 0.02$  (two-tailed *t*-test) and  $z = 2.37, p < 0.02$  (rank sum test). We cannot reject the null hypothesis magnitude (calm) = magnitude (fear) with  $t = 1.90, p < 0.07$  (two-tailed *t*-test) and  $z = 1.78, p < 0.08$  (rank sum test).

Table 2, Panel B reports the average peak amplitude of bubbles across markets by emotion treatment. The average peak amplitude of the bubbles after participants are induced to

Noussair, Robin, and Ruffieux, 2001; Hussam, Porter, and Smith, 2008). As Stöckl, Huber, and Kirchler (2010) point out, this measure treats undervaluation and overvaluations as equally contributing to a bubble. Thus, a market with a price rise from 50% below fundamental value to fundamental value and a market with a price rise from fundamental value to 50% above fundamental value are considered to experience equivalent bubbles. Our peak amplitude statistic measures only how high prices (the average price in a trading round) rise above fundamental values.

**Table 2.** Assessment of emotional reactions to the videos

Table 2 reports the distribution of survey results on emotional reactions to six videos ( $n = 185$ ). Each participant was randomly assigned to one of the six video clips. After watching a video clip, each participant was asked to choose (Panel A) the valence of his or her emotional reaction to the video on a five point scale; (Panel B) the intensity of his or her emotional reaction to the video on a five point scale; and (Panel C) which of six descriptions of emotional experiences best captured his or her feelings while watching the video (Afraid/Scared/Anxious, Bored/Jaded/Uninterested, Neutral/No Emotional Reaction, Excited/Eager/Enthusiastic, Sad/Gloomy/Depressed, and Calm/Relaxed/Peaceful). Panel A: The numbers in the last two columns indicate the differences defined as means of (column–row); \*0.10 significance; \*\*0.05 significance; \*\*\*0.01 significance. For example, *Peace in the Water* is more positive than *Franklin* and *Hostel* is more negative than *Knight & Day*. Panel B: The numbers in the last two columns indicate the differences defined as means of (column–row); \*0.10 significance; \*\*0.05 significance; \*\*\*0.01 significance. For example, *Hostel* is more intense than *Salem’s Lot* and *Peace in the Water* is less intense than *Mr. & Mrs. Smith*. Panel C: The shaded cells in Panel C represent the modal choices made by the participants for each of the six video clips.

Panel A. Valence of the video clips (1 = Clearly Positive; 5 = Clearly Negative)

	N	Mean	SD	Two-tail <i>t</i> -tests comparing the Exciting videos to the alternative videos	
				Knight & Day	Mr. & Mrs. Smith
Knight & Day	30	2.43	0.97		
Mr. & Mrs. Smith	31	2.51	0.96	−0.08	
Salem’s Lot	28	3.89	1.10	−1.46***	−1.38***
Hostel	32	4.53	0.84	−2.10***	−2.02***
Franklin	26	2.11	0.82	0.32	0.40*
Peace in the Water	38	1.68	0.81	0.75***	0.83***

Panel B. Intensity of the video clips (1 = Very Intense; 5 = Not Intense At all)

	N	Mean	SD	Two-tail <i>t</i> -tests comparing Exciting videos to the alternative videos	
				Knight & Day	Mr. & Mrs. Smith
Knight & Day	30	2.16	1.05		
Mr. & Mrs. Smith	31	2.29	1.00	−0.12	
Salem’s Lot	28	2.17	1.06	−0.01	0.11
Hostel	32	1.56	0.87	0.60*	0.73***
Franklin	26	3.27	1.08	−1.10***	−0.98***
Peace in the Water	38	3.05	1.27	−0.89***	−0.76***

Panel C. Distribution of most representative emotional reaction by video clip

	N	Reported emotional reaction					
		Afraid/ Scared/ Anxious	Bored/ Jaded/ Uninterested	Neutral (no emotional reaction)	Excited/ Eager/ Enthusiastic	Sad/ Gloomy/ Depressed	Calm/ Relaxed/ Peaceful
Knight & Day	30	3	4	2	20	0	1
Mr. & Mrs. Smith	31	2	8	2	17	0	2
Salem’s Lot	28	19	2	2	3	1	1
Hostel	32	25	0	3	0	4	0
Franklin	26	0	4	3	6	1	12
Peace in the Water	38	1	1	2	1	1	32

feel excited (512.3) is much greater than the average amplitude of bubbles after the participants are induced to feel calm (332.3) or fear (414.7). Again, for both tests, the peak amplitude of bubbles under the excitement treatment is greater than that under the calm and fear treatments. We reject the null hypothesis peak amplitude (excitement) = peak amplitude (calm) with  $t = 4.01$ ,  $p < 0.001$  (two-tailed  $t$ -test) and  $z = 3.66$ ,  $p < 0.001$  (rank sum test). We reject the null hypothesis peak amplitude (excitement) = peak amplitude (fear) with  $t = 2.04$ ,  $p < 0.05$  (two-tailed  $t$ -test) and  $z = 1.93$ ,  $p < 0.06$  (rank sum test). We cannot reject the null hypothesis peak amplitude (calm) = peak amplitude (fear) with  $t = 1.78$ ,  $p = 0.086$  (two-tailed  $t$ -test) and  $z = 1.38$ ,  $p = 0.167$  (rank sum test).

Our “calm” treatment provides a baseline of positive valence and low intensity emotion. A no-video treatment would not guarantee that participants felt no emotions, rather participants would begin the experiment with emotions prompted by coming to the experimental laboratory and by other events in their individual lives. While we do not run an additional no-video treatment, we cite four experiments with identical endowments and trading rules in Capinalp, Porter, and Smith (2001). Our calm treatment results in similar magnitudes and peak amplitudes to those in Capinalp *et al.*<sup>7</sup>

An examination of Figure 1, shows that (1) for the excitement treatment, the average price in the first round is well above fundamental value while for the calm and fear treatments first round prices are approximately the same as fundamental value, and (2) subsequent to round 1, prices in the fear treatment rise at about as much as prices in the excitement treatment and much more than in the calm treatment.

To formally test these observations, we analyze two additional metrics, Round 1 Amplitude, and Peak Amplitude minus Round 1 Amplitude:

3. *Round 1 Amplitude* measures the difference between the average price of the risky asset and its fundamental value in the first round of trading. *Round 1 Amplitude* is calculated as where  $\bar{P}_1$  is the average volume weighted transaction price in trading round 1, and  $f_1$  is the fundamental value (i.e., the expected value of remaining dividends) in trading round 1.
4. *Peak Amplitude–Round 1 Amplitude*. This measures the maximum increase in the amplitude of the bubble subsequent to the first round of trading.

Table 2, Panel C reports the amplitude of bubbles in round 1 across markets by emotion treatment. The Round 1 Amplitude of the bubbles after participants are induced to feel

7 Capinalp, Porter, and Smith (2001) report four identical experiments to ours with a mean magnitude of 156.70 and a mean peak amplitude of 438.50. We cannot reject the null hypothesis magnitude (calm) = m(“Capinalp *et al.*”) with  $t = 0.26$ ,  $p = 0.799$  (two-tailed  $t$ -test) and  $z = 0.60$ ,  $p = 0.549$  (rank sum test). We cannot reject the null hypothesis peak amplitude (calm) = peak amplitude (“Capinalp *et al.*”) with  $t = 1.91$ ,  $p = 0.073$  (two-tailed  $t$ -test) and  $z = 1.80$ ,  $p = 0.072$  (rank sum test). Although not statistically significant, our peak amplitude appears to be slightly higher than theirs. Capinalp, Porter, and Smith (2001) and earlier studies document that higher initial prices tend to be followed with lower peak amplitude. Indeed, our opening prices are higher than those of Capinalp, Porter, and Smith (2001). We believe that our higher opening prices originate from differences in training protocols. Capinalp, Porter, and Smith provide participants with detailed written instructions. In addition to written instructions, we run practice sessions simulating two rounds of trading. Opening prices in the practice rounds are closer to opening prices in Capinalp, Porter, and Smith. The somewhat higher opening prices in our experiment are likely the result of participants observing some price increase in the two practice rounds.

excited (72.0) is large and statistically greater than 0 ( $p < 0.001$  two-sided  $t$ -test). It is also much greater than the Round 1 Amplitude of bubbles after the participants are induced to feel calm (10.9) or fear (4.0). We reject the null hypothesis Round 1 Peak Amplitude (excitement) = Round 1 Amplitude (calm)  $t = 2.28$ ,  $p < 0.03$  (two-tailed  $t$ -test) and  $z = 2.11$ ,  $p < 0.04$  (rank sum test). We reject the null hypothesis Round 1 Amplitude (excitement) = Round 1 Amplitude (fear)  $t = 2.14$ ,  $p < 0.04$  (two-tailed  $t$ -test) but cannot reject with the Mann–Whitney test ( $z = 1.64$ ,  $p = 0.10$ ). We cannot reject the null hypothesis that Round 1 Amplitude (calm) = 0, Round 1 Amplitude (fear) = 0, or Round 1 Amplitude (calm) = Round 1 Amplitude (fear).

Table 2, Panel D reports the (Peak Amplitude–Round 1 Amplitude). The means of (Peak Amplitude–Round 1 Amplitude) are very similar after participants are induced to feel excited (440.3) and fear (410.7). We cannot reject the null hypothesis that (Peak Amplitude–Round 1) (exciting) = (Peak Amplitude–Round 1) (fear) ( $t$ -test,  $p = 0.52$ , Whitney–Mann,  $p = 0.89$ ). However, the means of (Peak Amplitude–Round 1 Amplitude) are quite a bit lower after participants are induced to feel calm (321.4). We reject the null hypothesis (Peak Amplitude–Round 1) (exciting) = (Peak Amplitude–Round 1) (calm)  $t = 2.44$ ,  $p < 0.02$  (two-tailed  $t$ -test),  $z = 2.28$ ,  $p < 0.03$  (rank sum test) and we reject the null hypothesis (Peak Amplitude–Round 1) (fear) = (Peak Amplitude–Round 1) (calm)  $t = 2.26$ ,  $p < 0.04$  (two-tailed  $t$ -test),  $z = 2.10$ ,  $p < 0.04$  (rank sum test).

To summarize, the magnitude and peak amplitude of bubbles are large and statistically significant in all three treatments ( $p < 0.001$ ). This was anticipated based on the choice of market parameters and prior work by Capinalp, Porter, and Smith (2001). The magnitude and peak amplitude in the excitement treatment are substantially and statistically larger than in the calm and fear treatments. In the first round of trading, prices rise well above fundamental value in the excitement treatment but do not do so in the calm or fear treatment. Over the next fourteen rounds of trading, prices rise similarly in the excitement and fear treatments and significantly more so than in the calm treatment.

## 6. Discussion

An advantage of the Smith, Suchanek, and Williams (1988) experimental setting is that it has been well studied. It is well known, for example, that bubbles are more likely when traders are endowed with more cash relative to risky assets, when dividends are paid after each round of trading rather than at the end of trading, when the order book is transparent, and when traders can buy on margin (Capinalp, Porter, and Smith, 2001). While we do not permit buying on margin, our allocations are cash rich (CR)—matching the CR endowments employed by Capinalp, Porter, and Smith (2001), dividends are paid after every round, and the order book is viewed by all participants; this is likely why we get bubbles in most experiments regardless of treatment.

As noted above, several features of the Smith, Suchanek, and Williams (1988) experimental setting have been criticized. In our experiments, criticized features of the experimental setting such as declining fundamental value, short sale constraints, and inexperienced traders are held constant across treatments. Thus, while these features may, in part, explain why bubbles arise in this setting, they do not explain our main finding that bubbles are significantly larger when participants begin trading in a pleasantly intense emotional state.

Our main finding is that excitement inflates bubbles compared with two alternative treatments: one of similar intensity but of negative valence (i.e., fear) and one of similar

valence but of much lower intensity (i.e., calm). The differences in the magnitude and amplitude of the bubbles are both economic and statistically significant. In the excitement treatment bubbles begin to form in the first round of trading while in the calm and fear treatments they do not. Interestingly, subsequent to the first round of trading, bubbles grow as much in the fear treatment as in the excitement treatment and significantly more so than in the calm treatment. That is, while the fear treatment initially suppresses bubble formation, the suppression is short lived in a “bubble-prone” market setting.

From a theoretical and empirical standpoint, fear represents a particularly interesting comparison treatment. As bubbles climb, some investors may fear that prices will collapse causing losses. Such fear is most likely to be felt by investors still in the market, some of whom may even vacillate between fear and excitement. So, fear can reduce a bubble relative to, at least, the excitement treatment.

However, fear, like excitement, is a high intensity—though negative—emotion. Intense emotions are physiologically arousing. Contextual cues are known to influence how people interpret arousing events (Schachter and Singer, 1962) and emotional arousal (e.g., fear as sexual attraction, Dutton and Aron, 1974). Lee and Andrade (2015), for instance, find that experimental participants who are manipulated to experience fear become excited while playing a casino-like game. In short, previous research has found that fear can turn to excitement when contextual cues suggest excitement and do not reinforce fear.

To better match our experiment to our motivation, we choose experimental market conditions that have been previously shown to generate bubbles. Our bubble-prone market experiment does not reinforce the fear but does reinforce excitement. Put simply, in our fear treatment, contextual cues and emotions are not aligned whereas in the excitement treatment, contextual cues and emotions are aligned. The latter is likely to be true not only in the laboratory but also in real markets. Real-world investors who are unexpectedly profiting from rapidly rising prices are likely to become excited and to remain excited as prices continue to rise.

In the same way that we have shown that excitement fuels a bubble, future research could investigate the extent to which fear can dampen “crash-prone” markets.

## 7. Conclusion

Historical accounts suggest that rapid, unexpected increased in wealth during the appreciation phase of asset pricing bubbles can lead investors to experience intense, positive emotions. We document, in an experimental setting, that magnitude and amplitude of bubbles is greater when, prior to trading, traders experience the high-intensity, positive emotion of excitement than when they experience either the low-intensity, positive emotion of calm or the high-intensity, negative emotion of fear. Thus, the excitement generated by rapidly rising prices in real-world markets may trigger emotions that lead to larger asset pricing bubbles.

## Appendix A: Asset-Pricing Market

### A. Instructions

This is an experiment in market decision making. You will be paid in checks for your participation at the end of the experiment. Different participants may earn different amounts. What you earn depends on your decisions and the decisions of others.

The experiment will take place through computer terminals at which you are seated. If you have any questions during experiment, raise your hand and a monitor will come by to answer your question.

#### A.1 The Situation

In this experiment, each participant will be given some *Cash* and *Shares* at the beginning.

When the experiment starts, you will participate in a market where *Shares* can be bought and sold between participants. You pay out of your Cash when you buy a share, and you get Cash when you sell a share.

The experiment is divided into *fifteen* consecutive trading *Rounds*. Within each round, the market is open for trading Shares.

Shares will earn the owners a cash income called *Dividend*. At the end of EACH round, EACH share will pay the owner a dividend. The dividend per round can be 0, 8, 28 or 60 cents, with equal chances. The dividends will be added to your cash amount immediately.

At the end of 15th round, a final dividend will be paid to the owner. Once that dividend is paid, the shares will be worth nothing. Your earnings will be based on the amount of cash that you accumulate. You can accumulate cash by buying and selling shares, and/or by holdings shares and collecting dividends.

Since  $(0 + 8 + 28 + 60) \div 4 = 24$ , the average dividend per round per share is 24 cents. That is, over many rounds, the average dividend per round tends to be 24 cents per share.

If you hold a share from round 1 to round 15, the share will pay you 15 dividends. The total dividend value you receive can be as low as 0 cents ( $15 \times 0 = 0$ ). This would be the result if all 15 of the dividends are 0. The total can be as high as 900 cents ( $15 \times 60 = 900$ ), if all 15 of the dividends are 60. Given that each possible dividend has an equal chance of occurring each round, the average total dividend value tends to be 360 cents ( $15 \times 24 = 360$ ).

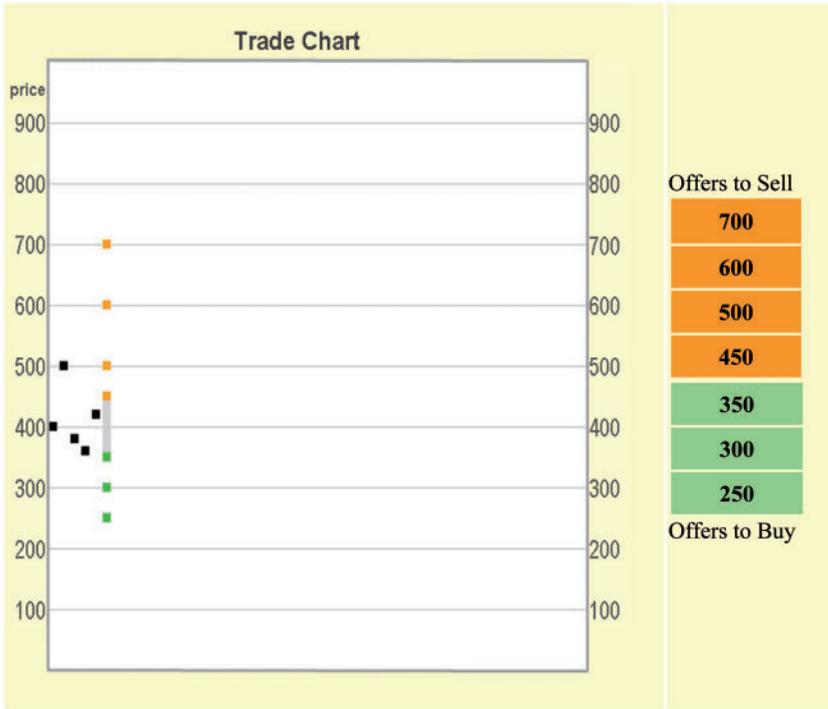
If you purchase a share in the 2nd round and hold it until the end of the 15th round, the average total dividend value will be 336 cents ( $14 \times 24 = 336$ ), and the total dividend could be as low as 0 cents ( $14 \times 0$ ) and as high as 840 cents ( $14 \times 60$ ).

Similarly, if you hold a share for any number of rounds,  $n$ , the share may return a dividend of as little as 0 cents or as much as  $n \times 60$  cents. The average dividend total tends to be  $n \times 24$  cents.

When a round is over, your Cash and Shares will carry over to the next round.

### A.2. How to Trade Shares?

Within each round, participants can buy or sell shares from one another by making offers to buy or to sell. First, let's see how offers are shown in the market.



Every time someone makes an offer to buy a share at a certain price, a GREEN dot will appear on the Trade Chart. Every time someone makes an offer to sell at a certain price, an ORANGE dot will appear on the Trade Chart. Once a trade is actually made, the trade will be shown as a BLACK dot on the Trade Chart. For example, right now shown on the Trade Chart, five trades that have taken place are: 400, 500, 380, 360, and 420.

Next to the Trade Chart, the Offers to Buy will be listed in increasing order, while the Offers to Sell will be listed in decreasing order. For example, the Offers to Sell are now 700, 600, 500, and 450; and the Offers to Buy are now 350, 300, and 250.

### Orders

Submit New Order

Buy	<input type="text"/>	Sell	<input type="text"/>
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Offers are made through “Orders” Section. To enter a new offer to buy, type your buying price next to “Buy” button on the “Submit New Order” row, and click “Buy” button to submit your offer.

To enter a new offer to sell, type your selling price next to “Sell” button on the “Submit New Order” row, and click “Sell” button to submit your offer.

## Orders

Submit New Order	Buy	<input type="text"/>	Sell	<input type="text"/>
Immediate Order	Buy	450	Sell	350

In the “Orders” section, the second row is “Immediate Order”, where you can accept existing offers in the market.

The “Buy” box shows you the lowest offer you can buy from at the point of time. For example, the price showing right now is 450. This indicates the best selling offer in the market is now 450. If you click on the “Buy” button next to it, you will immediately buy a share at the price of 450.

The “Sell” box shows you the highest offer you can sell to at the point of time. For example, the price showing right now is 350. This indicates the best buying offer in the market is now 350. If you click on the “Sell” button next to it, you will immediately sell a share at the price of 350.

## Cancel Orders

Click on an order to Cancel it

500

Whenever you enter new offers to buy, or sell, you will have those offers appear as buttons under “Cancel Orders” section. By clicking on these buttons, you can take them out of the market. For example, it is showing right now that you have an offer at 500. If you click on the button, you withdraw your offer at the price.

### A.3 Examples

Let’s see an example of a trade below. Note that the prices here are arbitrarily chosen and are irrelevant to the actual prices that will happen in the experiment.

Suppose you have 3 shares and 1050 in Cash at the start of a round, and you make one transaction purchasing a share for 420 cents within the round. If the dividend for the round is 60 cents, then:

Your share holdings will increase from 3 to 4 units.

You will pay 420 out of your Cash holdings, and for the round you will receive a total dividend of  $(60 \times 4 \text{ shares}) = 240$ . Thus your cash will decrease by  $(420 - 240) = 180$  cents. Your new cash holding will be  $(1050 - 180) = 870$  cents.

Another example:

Following the previous example, you now have 870 cash and 4 shares. Suppose in the next round you make two transactions. You sell one share for 300 and another share for 350. If the dividend for the round is 8, then:

Your share holdings will decrease from 4 to 2 units.

You get  $(300 + 350) = 650$  from your sales of 2 shares, and you will receive a total dividend of  $(2 \text{ shares} \times 8) = 16$ . Your Cash holdings will increase by  $(650 + 16) = 666$  cents. Your new cash holding will thus be  $(870 + 666) = 1536$  cents.

#### A.4 Practice Session

This experiment will last for fifteen rounds. Each round will last for 3.5 min.

Before the actual fifteen rounds start, we will give you a *Practice Session*, during which you can practice making offers and making transactions.

When the Practice Session is over, it will take some time to re-initialize and configure the trading program. The preparation could take around 5–8 min.

[Below, we introduce why we would play the video.]

[Same Video within treatment]

Because the waiting is a bit long, we will play a *video* clip. We intend to use the video in another experiment and want to get some feedback from you. After you've finished watching the clip, please answer a few questions about it. Note that the video is not related to your earnings today. So thank you in advance for helping out.

[Two Videos within treatment]

Because the waiting is a bit long, we will play some video clips. Since we intend to use the videos in another experiment, we've selected a few *different* video clips. You will be randomly assigned to *one* of them. After you've finished watching the clip, please answer a few questions about it. Note that the video is not related to your earnings today. So thank you in advance for helping out.

In the main task, a short survey followed the emotion induction to check the manipulation. As you can see below, this emotion induction check varied by treatment and sometimes within a given treatment (by video clip). Hence, as described in the main text, a separate but standard emotion induction check was conducted to assess valence, intensity, and emotion type (see Appendix B).

After watching the videos, participants answered the following questions.

Questions asked after Mr. & Mrs. Smith and after Franklin

1. How did this movie clip make you feel (from 1 = very calm/relaxed to 9 = very active/excited)

2. Do you think this clip is a nice filler task to be used in future experiments?

\_No\_Yes

Questions asked after participants watched Knight & Day, Salem's Lot, or Hostel

1. Please indicate (a) the emotional state that BEST describes what you've experienced while watching the video clip—only one option allowed. Then, indicate the intensity of the selected emotional experience.

Anxiety/Fear/Nervousness \_\_\_ (1 = very little; 9 = very much)

Excitement/Pleasure/Enthusiasm \_\_\_ (1 = very little; 9 = very much)

2. Do you think this clip is a nice filler task to be used in future experiments?

No  Yes

Questions asked after participants watched "Mr. & Mrs. Smith + Knight & Day", and "I am Sam + The Champ" (see footnote 3 in the main text)

1. Please indicate the emotional state that BEST describes what you've experienced while watching the video clip—only one option allowed. Then, indicate the intensity of the selected emotional experience.

Sadness/Distress/Unhappiness \_\_\_ (1 = very little; 9 = very much)

Excitement/Pleasure/Enthusiasm \_\_\_ (1 = very little; 9 = very much)

2. Do you think this clip is a nice filler task to be used in future experiments?

No  Yes

Questions asked after participants watched "Peace in the Water"

1. Please indicate if the video you've just watched was either pleasant or unpleasant—only one option allowed.

Pleasant

Unpleasant

2. How did this movie clip make you feel (from 1 = very calm/relaxed to 9 = very active/excited)?

## A.5 Feedback

(Please provide us some feedback on today's experiment. Thank you in advance!)

Q1: What is the purpose of the study?

Q2: What was your strategy in the experiment?

Q3: Did you ever buy shares at prices above the remaining average dividend value? If so, what is your reason?

Q4: Did you encounter any difficulty in the experiment?

## A.6 Summary

1. You will be given an initial amount of Cash and Shares at the very beginning.

2. Each share pays the owner a dividend of either 0, 8, 28, or 60 cents at the end of EACH of the fifteen trading rounds. The dividend amounts have the same chance of being

drawn at the end of a round. Thus, the average dividend per round per share is 24 cents. Between rounds, you will be given some short time to review your holdings.

3. You can submit offers to BUY shares and offers to SELL shares.

4. You can make immediate trades by buying at the current lowest offer to sell or selling at the current highest offer to buy.

5. The market lasts for fifteen rounds. At the end of round 15, there will be one last dividend payment. After that the share expires and is worth nothing to you.

6. We will give you a Practice Session whereby you become familiar with the trading program. After that we will re-initialize the program and get ready for the actual session.

The instructions are over. If you have any question, raise your hand and consult the monitor. Otherwise, click “Start”, login with the “Account Name” on the note on your desk, and wait for the Practice Round.



## Appendix B—Emotion Induction Check

### Screen 1

#### MAIN TASK

On the following screen, you will be asked to watch a movie clip. After that, a few specific questions about the video will be asked.

Please, click on the continue button and pay careful attention to the movie clip.

### Screen 2

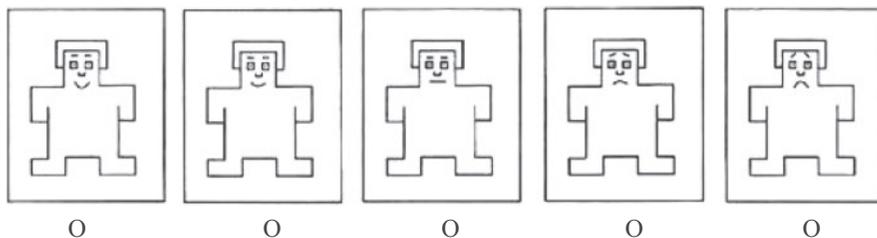
#### EMOTIONAL REACTION TO THE VIDEO CLIP

Now please indicate on the two manikin-like scales below how you emotionally reacted to the video clip.

*The overall emotional experience I felt while watching the video clip was ...*

Clearly Positive

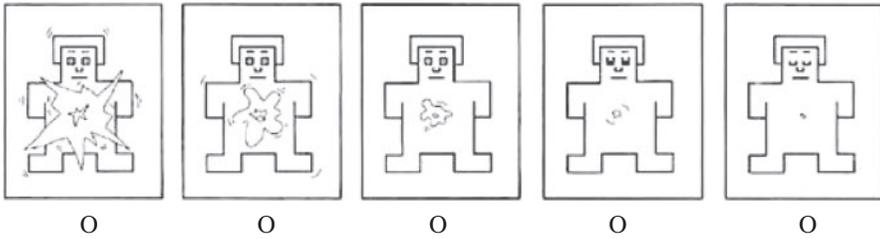
Clearly Negative



The overall emotional experience I felt while watching the video clip was ...

Very Intense

Not Intense at All



### Screen 3

#### EMOTIONAL REACTION TO THE VIDEO CLIP

Please indicate the emotion that best captures what you've felt while watching the movie clip.

Only one option allowed:

The movie clip made me feel ...

- Afraid/Scared/Anxious
- Bored/Jaded/Uninterested
- Neutral (no emotional reaction)
- Excited/Eager/Enthusiastic
- Sad/Gloomy/Depressed
- Calm/Relaxed/Peaceful

### Screen 4

What was the main story of the movie clip? Please describe it in detail.

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Thank you!

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