Vividness and Trading Behavior in an Experimental Asset Market

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We investigate the impact of vividness on trading behavior in an experimental asset market, by contrasting vivid with pallid presentation of information. Vivid information is characterized as emotionally engaging and proximate, while pallid information is purely factual. Our design enables us to isolate the effect of vividness by controlling the content of the information irrespective of the presentation. We find that vividness elevates investor attention, as measured through order-book composition and market variables. Interestingly, vividness can both distract as well as focus investors’ attention depending on the nature of the underlying information. We also find evidence that vividness has a catalyzing effect on existing behavioral biases. Independent of information content, vividness exacerbates difference of opinion amongst investors with heterogeneous priors. In addition, we find that strong market sentiment develops when a large proportion of overconfident investors receive prior-confirming information in a vivid manner. This results in the concurrence of high sentiment, returns and turnover.

Key words: Vividness, Trading Behavior, Experimental Asset Market

1. Introduction

Investors receive signals about macro-economic, industry- and company-specific variables based on which they make investment decisions. The impact of such signals on investors will obviously depend on its informativeness, i.e. its relevance and reliability. The role of the informativeness of the signal in influencing investor reaction is well examined in the literature. However, before information pertinent to a company becomes a public signal and reaches an investor, it travels through the company’s public relations department or an investor relations firm and often also through an editorial team of a news agency specializing in the dissemination of information. Although the intermediaries’ conversion of such information to news is a major component of the information dissemination process, its role in influencing investors’ perception and reaction to information is
not well examined and understood. Our study uses an experimental approach to explore the role of presentation of information, by examining its influence on trading behavior through order book and market variables. In our experimental design, presentation of information utilizes the concept of “vividness,” where vividness of information has variously been characterized as the extent to which it is emotionally engaging, imagery producing and proximate (Nisbett and Ross 1980). Such a form of information presentation is juxtaposed in contrast to information that is purely statistical, abstract or base-rate, i.e. pallid.

The role of vividness in enhancing the newsworthiness of information is well documented. Kennamer (1988) suggests that vividness of information is one of the prime determinants of its newsworthiness. Prior studies have indicated that decision makers react more strongly to vivid information rather than that of a purely statistical and pallid nature (Nisbett and Ross 1980). Damasio (1994) categorizes vividness of description of future outcomes as one of the most important determinants of emotional reactions to such outcomes. Borgida and Nisbett (1977), through a study that contrasted the differential effects of mean course evaluations versus face-to-face comments about the courses, find that people tend to underweight the informativeness of base rate data and suggest that this is due to its abstract and pallid nature. Numerous other studies also support this finding that relevant statistical, base-rate and abstract information are underweighted compared to cases, scenarios and examples that are more vivid (Kahneman and Tversky 1973, Reyes et al. 1980, Bar-Hillel 1980, Hamill et al. 1980, Bar-Hillel and Fischhoff 1981, Tversky and Kahneman 1983, amongst others). Collins et al. (1988) find that vivid messages are more persuasive than pallid ones. They conclude that it is the attention generating ability rather than ease of recall which makes the vivid messages more persuasive. Furthermore, Clark and Rutter (1985) find that vivid information increases people’s confidence in their own opinions and similarly Odean (1998) contends that such distorted reaction to information (i.e. the undervaluing of pallid statistical information) is due to overconfidence. From the perspective of a financial setting, Hirshleifer and Teoh (2003) argue that faced with an overload of information, investors with limited attention are attracted towards information with certain characteristics, vividness being one.
Limited attention theory, which posits that cognitive constraints limit the ability of individuals to pay attention to all relevant information, provides an obvious perspective from which to study the impact of vividly presented information. Psychology research finds ample evidence in support of limited attention due to limits on the information processing capacity of humans (see Pashler and Johnston 1998, for a summary of the findings). The concern within the context of financial markets is that investors have limited attention when it comes to recognizing and interpreting information. One implication of limited investor attention, addressed by Hirshleifer and Teoh (2003) amongst others, is that investors can perceive the same information differently depending upon its presentation. Another implication is that extraneous information inhibits reaction to relevant information, termed as the investor distraction hypothesis by Hirshleifer et al. (2009).

Our findings are consistent with both of these implications of limited attention of investors. We find that vividly presented information induces behavior which is significantly different from that in the presence of non-vivid or pallid information. Furthermore, we find that when extraneous information is presented in a vivid manner it overrides the impact of more relevant but non-vividly presented information. Our results also show support for the presence of heterogeneous priors amongst investors. Hong and Stein (2007) argue that in a scenario where investors have heterogeneous priors, news that generates more attention leads to more disagreement amongst investors. This translates into higher trading volume and under short-selling constraints a tendency for prices to go up. We find that vividness increases disagreement amongst investors, consistent with the presence of heterogeneous priors. Finally, our results indicate that vividness exacerbates the overconfidence of investors with limited attention, which is consistent with other studies that find greater attention by overconfident investors amplifies the effect of their overconfidence (Hou et al. 2008). As Lim and Teoh (2010) argue, since greater attention by investors translates into more active participation in trading, any bias (such as overconfidence) exhibited by investors could have a greater impact on trading variables.

In our experiment, information (signals) from which news about future dividends is generated is of two types depending on the degree to which it helps predict the future dividend. We classify
these information sources as highly reliable and non-reliable. We vary reliability of information by sometimes revealing highly reliable (statistically significant) information on actual future cash flows. At other times we only provide information which is sourced from a survey of uninformed traders’ outlook about future cash flows, making the information non-reliable. Our survey of traders enables us to generate information whose non-correlation with future cash flows is transparent and known to all subjects. This information from the survey is provided to the subjects in all trading periods. As discussed earlier, we employ the concept of vividness for the presentation of information, where both reliable and non-reliable information are presented to the subjects in one of two distinct forms: pallid and vivid. The pallid dissemination of information is purely factual, while vivid information is constructed by using language from actual news releases of real-world companies. By introducing variations in presentation of information while controlling for its statistical reliability, our motivation is to isolate the effect of presentation of information on trading behavior.

We introduce two risky assets and one risk free one (cash). The two risky assets are stock N (with information flows) and stock X (without information flows). Stock X is introduced to examine any spill-over effect of attention on stock N on an unrelated stock which is not directly subjected to any attention effect.

Our experimental approach is designed to mitigate an important issue that archival studies face in this area. With archival data based on news releases it is difficult to isolate the true impact of differences in presentation, since this requires controlling for the informative content of news while estimating the effect of changes in presentation on trading behavior. For example, an implication of limited attention of investors is that news releases when broadcast in a more “attention-grabbing” manner would garner greater response from traders, even if the substantive content of the news release were to be the same. Our experimental approach allows this by varying the attention-grabbing aspect (i.e. vividness) of the news while keeping its informativeness or reliability fixed.

1 For brevity we sometimes refer to highly reliable information as reliable information.
2 Our approach of generating information flows based on reliability and presentation could be related to the concept of weight and strength of information introduced by Griffin and Tversky (1992). In their terminology, weight refers to the statistical reliability of information while strength refers to the saliency of the information.
3 See for example Hong and Stein (2007) who state “in particular, a focus on limited attention suggests that, holding fixed the substantive content associated with a news release, the response of prices and trading volume to the release will be larger when it is broadcast in an “attention-grabbing” manner” (italics are ours for emphasis).
Keeping the reliability of the information independent of the mode of presentation in our design enables us to isolate the attention effect (if any) due to vividness in presentation, without any confound from the reliability of such information. Another benefit of our experimental approach is that it enables us to circumvent the endogeneity issue that typical archival studies would encounter. This endogeneity problem arises due to the contemporaneous nature of archival data that makes disentangling the direction of causality difficult, i.e. is attention due to media coverage causing abnormal returns or are abnormal returns triggering media coverage. An experimental approach, by allowing us to observe the effect of information flows on subsequent trading behavior, removes this endogeneity problem associated with contemporaneous data.

The scheme for the rest of the paper is as follows. Section 2 discusses related work. Section 3 provides the experiment design, including the treatment and session information. Section 4 develops our hypotheses. Section 5 provides the regression models and discusses the results. Section 6 concludes.

2. Related Work

As discussed earlier, numerous psychology studies establish that vivid presentation or description of an event or information induces more attention and reaction. Therefore, in the presence of limited investor attention, vividness should be expected to induce changes in investor behavior. To understand the expected changes in investor behavior due to vividness, we draw on studies that examine the impact of limited investor attention on financial markets. Such studies fall into two main categories. One category examines limited attention from the perspective of investor distraction due to information overload. The other category focuses on prominence and ease of processing of information as a tool to attract attention. Some examples of studies which fall in the first category are those which find stronger post-announcements drift for earnings announcements: made on Fridays compared to other weekdays (DellaVigna and Pollet 2009), made on days with a relative large number of announcements (Hirshleifer et al. 2009) and made after trading hours (Francis et al. 1992). Studies in the second category include Peress (2008) and Engelberg (2008). Peress (2008) finds weaker earnings drift for earnings announcements which are covered in the
Wall Street Journal. Engelberg (2008) categorizes news as either quantitative or qualitative information and finds that earnings announcements with more qualitative information have stronger post-announcement drifts compared to those with more quantitative information.

Following Kennamer (1988), who argues that news creation by media entails the systematic creation or enhancement of vividness, our approach of examining the effect of vivid information finds resonance in studies which examine the effect of media coverage on stock market outcomes using archival data. One important channel through which news is argued to influence stock markets is the “attention effect” of media coverage on investors, which implicitly assumes limited investor attention. Prior studies report evidence that media coverage stimulates returns (Fang and Peress 2009, Kothari et al. 2009), trading volumes (Barber and Odean 2008, Engelberg and Parsons 2011) and other aggregate market outcomes (Dougal et al. 2012, Tetlock 2011). Tetlock (2007) measures the interaction between media reports and stock returns and links unusually high or low pessimism to high market volume. This he argues is contrary to media content revealing new information about fundamental asset values. Solomon (2012) examines the role of investor relations firms in “spinning” press releases and finds that such firms generate more media coverage of positive press releases than negative ones for their clients, which increases announcement returns. Around earnings announcements however, returns are significantly lower.

By incorporating the presentation of information as a determinant of trading behavior, we also investigate the role of qualitative information in asset markets. Earlier studies that have examined whether qualitative information has predictive power on earnings and stock returns, find that particular negative words in annual reports predict low earnings and returns (Li 2006). Similarly, Tetlock et al. (2008) find that the fraction of negative words in news stories predicts low earnings, documenting brief underreaction on negative news stories. A standard explanation for this relationship postulates that in order for qualitative aspects of news to affect stock returns, it must have some informativeness embedded in it regarding cash flows or investors’ discount rates (Campbell and Shiller 1987). The implicit assumption there is that the qualitative aspect complements the informativeness of the quantitative one. In other words, these studies purport to
examine the extent of residual information embedded in the qualitative aspect of news. However there exists an alternative possibility, the one we examine, wherein the qualitative aspect of news could influence the perception of investors towards the information embedded in the news without adding to its informativeness.

While we examine the impact of presentation of information, prior experimental work on attention in financial information settings has primarily focused on the effect of placement of the information. Hirst and Hopkins (1998) and Maines and McDaniel (2000) find that when information was placed in a prominent location (such as income statement) it was more likely to be considered as relevant for future performance estimates by subjects. In other experimental work on financial information, Bloomfield (1996), Nelson et al. (2001) and Andreassen (1990) amongst others, examine over- and under-confidence of investors based on Griffin and Tversky (1992) theory of differences in confidence judgement depending on the type of information they receive. These experimental studies do not employ a market clearing mechanism for determining prices, instead using a coin-flipping exercise or an exogenously given price pattern.

3. Experiment Design

We ran a laboratory based asset market experiment. The subjects in our experiment were drawn voluntarily from the pool of business students, both undergraduate and graduate. They were assigned the role of asset market traders. The subjects were paid in cash an amount depending on their decisions during the experiment and an initial show-up fee. The actual amount was determined through the portfolio value at the end of each trading session. They earned on average an amount equivalent to US$30 for a three hour session. Each trader was given an initial endowment/portfolio of cash (25000 experimental currency units) and 250 shares each of the two stocks N (with information flows) and X (without information flows), that could either be bought or sold every period. In our setup both stocks pay a dividend that was random depending on the state, where the dividend amount and the state determination are independent for the two stocks.

4 Students on average can earn an equivalent of US$5 per hour from working on campus.

5 Subjects were not allowed to short stocks in order to prevent potential default in payments and bankruptcies.
Cash not used to purchase shares accrues a known risk-free return (4% in all sessions). Once markets clear, dividends and interest from cash holdings are paid at the end of each trading period. The dividend determination process for both stocks follows a random walk process. The specific parameters of the process can be observed from the figures 1 and 2 for stocks N and X respectively.

Figure 1  Dividend-Determination Process for Stock N

Figure 2  Dividend-Determination Process for Stock X

The shares of each asset have a redemption value which is determined by the last period dividend. Since our dividend-determination process follows a random walk without drift, in any period
the future expected dividend is exactly equal to the current period dividend (see figure 3(a)). Therefore the expected redemption value for a stock is the ratio of the current dividend over the risk free rate and incrementally changes in each trading period depending on the realized dividend (see figure 3(b)). The program interface provides the subjects with the expected redemption value for each stock at the end of each trading period.

**Figure 3  Expected Dividend and Determination of Redemption Value**

![Figure 3](image)

Trades are arranged through a standard limit-order process. At the start of a period, each trader can submit a limit order to buy (bids) and/or sell (asks) shares by specifying the number of shares and the maximum purchase/minimum sale price (see figure 4(a) for the interface). All bids and asks are arrayed into a pseudo demand and supply function respectively, which determines the market clearing price and volume. Once market clearing takes place, subjects are informed about their order execution result, the market price and market trading volume. Subjects are also informed about the realized dividend, their total dividend earnings and their portfolio value based on market prices of the assets (see figure 4(b)).

### 3.1. Information and Construction of News

The type and sequence of information flows is the primary treatment variable, where information with different reliability-presentation combinations were released in different sequences to subjects in order to investigate their effect on trading decisions. The time allocated to the subjects for reading the information is the same irrespective of the reliability-presentation combination (90 seconds in all sessions). Non-reliable information is determined by subjects’ guesses on the
direction of future dividend. This was implemented through a survey before each trading period, where subjects selected the direction of future dividend of stock N, i.e. whether they expect the dividend for the stock to increase (positive outlook) or decrease (negative outlook). As there is an equal probability for the dividend of stock N to increase or decrease (refer to figure 1), the survey results do not provide any real objective information regarding the expected dividend for stock N, though they might provide information regarding the sentiment (optimistic or pessimistic) of traders. The subjects were paid an equivalent of US$0.12 if their outlook choice reflected the true outcome. In addition, three subjects randomly chosen in each period had their survey choices, unknown to them, deliberately changed (if needed) to the true outcome. All subjects were made aware of this arrangement beforehand. The number of subjects in all sessions was sufficiently high that the survey result after this change remains an unreliable predictor of future dividend. Our objective behind the slight alteration of the survey results is to add marginal (albeit statistically insignificant) information to an otherwise purely noisy predictor.

Highly reliable information on the other hand, provides statistically relevant information about the next period dividend. This information resolves the uncertainty regarding the next period state (positive or negative) in the dividend-determination process (refer to figure 1) by revealing the expected next period dividend conditional on the revealed state. Irrespective of whether subjects are presented with highly reliable information or not, they were always provided the survey-predicted dividend.
With respect to presentation, information was provided in a pallid or a vivid manner. When presented in a pallid manner, information on expected dividend (irrespective of low or high reliability) was given factually. When information was presented in a vivid manner, it was contextualized to make it more proximate. Based on this we create four different types of information regimes: Non-Reliable Pallid Information (NR-P), Non-Reliable Vivid Information (NR-V), Highly-Reliable Pallid Information (HR-P) and Highly-Reliable Vivid Information (HR-V). We also have a baseline treatment with no information, in which case subjects did not have access to any information (except the distribution of the dividends) before they began trading, including information on survey results.

In all information trading periods, subjects always receive the tabulated results from the survey as well as a textual summary. The format of this information is as follows:

**Non-Reliable Pallid**: A survey of trader expectations shows that they on average anticipate the next dividend payout for Stock MZQ to be $…

The above information is a noisy predictor of future dividends since it is derived from the survey of traders (subjects). This is the only information displayed to subjects in the Non-Reliable Pallid regimes. In addition to the above information, in Highly-Reliable Pallid regimes subjects also receive a highly reliable signal about future dividend through the process explained earlier. This information is presented in the following format:

**Highly-Reliable Pallid**: Analysts forecast of the next expected dividend payout for Stock MZQ is $…

In vivid information regimes, the subjects are also presented the same information in a format that takes into cognizance whether the forecast of the dividend derived from the survey (non-reliable states) or from the resolution of the state (highly reliable states) is higher or lower than the current dividend (i.e., the unconditional expected dividend). When the information reveals the expected dividend to be higher (lower) than the current dividend, we term it as positive (negative) information. As argued earlier, a fundamental characteristic of news is that it contains a vivid representation of information. Therefore, we base our version of vivid representation
of information on the format in which information is represented commonly in corporate news releases. To accomplish this we first collect a wide sample of corporate news reports from the Lexis-Nexis database. From our analysis of these news reports, we identified that the expected performance of companies is commonly rationalized or motivated by either information about the company’s product market or financial position or both. Our construction of news (vivid representation) draws on these characteristics of corporate news reports as reflected below.

**Non-Reliable Vivid (Positive)**: A business survey of traders with experience in trading of Stock MZQ (SYM:MZQ) reveals that they expect a strong improvement in the performance of Company MZQ. The optimism of the traders could be attributed to improved market demand for the company’s products. In addition the results from the survey indicate that traders have an increasingly positive outlook regarding the financial position of the company. Traders in the survey expect the next dividend for Company MZQ to increase to $... 

**Non-Reliable Vivid (Negative)**: A business survey of traders with experience in trading of Stock MZQ (SYM:MZQ) reveals that they expect a strong decline in the performance of Company MZQ. The pessimism of the traders could be attributed to worsening market conditions for the company’s products. In addition the results from the survey indicate that traders have an increasingly negative outlook regarding the financial position of the company. Traders in the survey expect the next dividend for Company MZQ to decrease to $... 

**Highly-Reliable Vivid (Positive)**: Independent analysts from major financial institutions forecast a strong performance by Company MZQ (SYM:MZQ). The optimism of analysts is driven by a surge in orders for the company’s products. Moreover, the analysts’ opinion is reinforced by the solid financial condition of the company. All analysts unanimously agree on the positive outlook for Company MZQ and predict the next dividend to rise to $...
Highly-Reliable Vivid (Negative): Independent analysts from major financial institutions forecast a poor performance by Company MZQ (SYM: MZQ). The pessimism of analysts is driven by a crash in orders for the company’s products. Moreover, the analysts’ opinion is reinforced by the gloomy financial condition of the company. All analysts unanimously agree on the negative outlook for Company MZQ and predict the next dividend to fall to $…

The emphasized parts deal with the performance and its link to the product market and financial position of the company. Note that the subjects received all the above information in plain text without the emphases. By design, the news is completely analogous for the negative and positive versions and uses similar constructs for the non-reliable and reliable versions. Also, the wording in the reliable version is stronger by design compared to the non-reliable one in order to reflect the quality of the information.

3.2. Treatments

We run a total of six different treatments comprising six experiment sessions. Each treatment has twenty trading periods and was run twice, on different cohorts of subjects. This provides us with individual and aggregate market data on 240 trading periods, with number of subjects varying from 35-46 depending on the session. In five of the treatments, participants receive information in each trading period, while in one treatment no information is released. The five “information” treatments differ from each other based on whether the information is vivid (V) or pallid (P) before its release and the pattern of the release over the trading session. The reliability of the information displayed to the subjects on the other hand is determined randomly, with equal probability on whether the information is reliable or non-reliable. Therefore, the two aspects of the information flows in our experiment are characterized by randomly determined reliability and controlled determination of packaging of information. The different treatments are defined as follows:

- **No Information**: No information was provided, including survey results.
- **All Pallid**: Information was provided in every period in a pallid fashion.

Note that the subjects were fully informed about the source of both the reliable and non-reliable information.
All Vivid: Information was presented in every period in a vivid manner.

Block Vivid: Sequence of five information presented in a vivid manner followed by five information presented in a pallid manner and repeated.

Decreasing Vividness: Decreasing sequence of vivid versus pallid information in two blocks of 10 trading periods each: V V V P P V P V P P repeat 10 periods.

Increasing Vividness: Increasing sequence of vivid versus pallid information in two blocks of 10 trading periods each: P V P V V P V V V P repeat 10 periods.

Table 1 provides information on the number of subjects and the treatments in each session.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Session 1</th>
<th>Session 2</th>
<th>Session 3</th>
<th>Session 4</th>
<th>Session 5</th>
<th>Session 6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Information</td>
<td>–</td>
<td>43</td>
<td>–</td>
<td>–</td>
<td>35</td>
<td>–</td>
<td>78</td>
</tr>
<tr>
<td>All Pallid</td>
<td>–</td>
<td>–</td>
<td>35</td>
<td>–</td>
<td>–</td>
<td>36</td>
<td>71</td>
</tr>
<tr>
<td>All Vivid</td>
<td>46</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>36</td>
<td>82</td>
</tr>
<tr>
<td>Block Vivid</td>
<td>46</td>
<td>–</td>
<td>–</td>
<td>45</td>
<td>–</td>
<td>–</td>
<td>91</td>
</tr>
<tr>
<td>&gt; Vividness</td>
<td>–</td>
<td>43</td>
<td>35</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>78</td>
</tr>
<tr>
<td>&lt; Vividness</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>45</td>
<td>35</td>
<td>–</td>
<td>80</td>
</tr>
</tbody>
</table>

Each treatment had twenty trading periods. There was a practice game at the beginning of each treatment.

3.3. Survey Outcomes

Figure 5 provides the distribution of outcomes from the survey of subjects regarding their outlook on the next dividend. The outcome from the survey is revealed to the subjects before the commencement of trading in each period. Importantly, the survey outcomes generated information which is uncorrelated to the dividend process and therefore formed the basis for information generated in non-reliable states. Survey outcomes reveal that in about 90 percent of trading periods a majority of subjects chose a positive rather than a negative outlook. Consequently, the information flow in an overwhelming number of non-reliable states was positively qualified, with the extent of increase in expected dividends depending on the fraction of subjects indicating a positive outlook.
4. Hypotheses

We develop hypotheses on the effects of vividness on the order book composition and on market outcomes. While the order book reflects the direct impact on trading behavior, analyzing the market outcomes indicates whether the order book effects persist at the market level. Further, the hypotheses enable us to examine how vividly presented information interacts with behavioral factors known to impact investor decision making.

Specifically, we develop four hypotheses. Hypotheses 1 and 3 predict the impact of vividness on trading behavior from the sole perspective of investors with limited attention. Hypotheses 2 and 4 develop the interaction effects of overconfidence and limited attention on investors with heterogeneous priors. Our hypotheses can also be interpreted from the perspective of the interaction of vividness with information content. Hypotheses 1 and 2 describe the effects of vividness irrespective of the relevance of the information. Hypotheses 3 and 4 interpret the differential reaction of investors toward the vivid presentation of non-reliable compared to reliable information.

Through hypothesis 1 we demonstrate the attention-grabbing effect of vividness. Based on our earlier discussion, we hypothesize that vividness creates an elevation in attention levels of investors, which we attribute to their limited attention, leading to more participation in trading.
**Hypothesis 1** (Attention grabbing hypothesis): When information is presented vividly, attention as measured by the order book size will be elevated compared to states where information is presented in a pallid manner.

Next we examine how vividly presented information interacts with overconfidence in investors who also exhibit heterogeneity in their prior beliefs. Prior studies in psychology by Lord et al. (1979), Nisbett and Ross (1980) and Fiske and Taylor (1991) find that subjects overweight information that is consistent with their existing beliefs and readily dismiss information that does not, suggesting an overconfidence bias. In financial settings there is a substantive literature that model agents whose biased beliefs inhibit them from forming correct expectations (Barberis et al. 1998, Daniel et al., 1998, amongst others). In our experimental design, in the absence of any other information dividends are expected to have an equal likelihood of going up or down. However, those agents whose beliefs inhibit accurate updating of expectations could assign a greater (smaller) than equal chance to the dividends going up thereby exhibiting optimistic (pessimistic) beliefs.

The survey results from figure 5 show that a significant majority of subjects indicate an optimistic outlook about the future state. In addition, the variation in the fraction of subjects indicating a positive outlook (0.4-0.91) during the trading session suggests the subjects’ beliefs interact with events to shape their future outlook. In non-reliable states, our survey provides a feedback mechanism such that subjects whose opinions match with those of the majority receive a confirmatory signal. Similarly, in reliable states, the statistically reliable information provides a confirmatory effect on 50% of the subjects on average. With overconfidence, subjects who receive the confirmatory signal will overreact, while others (those whose opinions deviate from the majority) who do not receive a confirmatory signal will not overreact. This effect, we argue tends to widen the range of limit order prices. When information is presented in a vivid manner, it leads to amplification of this overreaction in both reliable and non-reliable states. This leads to the following hypothesis:

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7 Of course not all subjects who indicate a positive (or negative) outlook necessarily are optimistic (or pessimistic). But the results are consistent with a significant percentage of optimistic subjects. This is also well documented in prior studies, for example Marks (1951), Irwin (1953) and Langer and Roth (1975) show that subjects are unrealistically optimistic about pure chance events.
**Hypothesis 2** (Difference of opinion hypothesis): When information is presented vividly, the order book displays a wider array of limit order prices, which gets reflected in higher variance in bids and asks and also in greater disparity between average asks and bids.

Creating attention through vividness could have different consequences depending on the type of information being presented. We expect vivid portrayal of reliable information to focus attention on the relevant distributional properties. We expect vivid presentation of non-reliable information on the other hand to distract from the relevant. Such a consequence of vividly presented non-reliable information resonates with the investor distraction hypothesis of Hirshleifer et al. (2009) which contends that with limited investor attention extraneous news would impede market reaction to relevant news. Therefore, we develop a set of hypotheses to formalize our expectation on market reaction to vividly presented information conditional upon its content, i.e. non-reliable or reliable.

**Hypothesis 3a** (Investor distraction hypothesis): Vivid portrayal of non-reliable information distracts traders with limited attention from relevant distributional information. We expect the resultant mispricing to be stronger when the vividly presented non-reliable information is also prior-confirming.

**Hypothesis 3b** (Investor focus hypothesis): Vivid portrayal of reliable information focuses investors with limited attention on relevant distributional information. We expect investors to update their priors more strongly when the reliable information is presented in a vivid manner leading to price correction.

Hypothesis 2 predicts vividness to amplify disagreement of opinion amongst subjects leading to greater variation of limit order prices across subjects potentially increasing turnover. In the next hypothesis we examine the implication of this vividness-driven disagreement of opinion on trading volume and price levels. Hong and Stein (2007) argue that in the presence of short-selling constraints, increase in news releases would be expected to increase prices when agents have heterogeneous priors, due to an increase in the level of sentiment. They also argue that trading volume is an indicator of market sentiment. Therefore, higher trading volume indicates higher
current returns and therefore future lower expected returns. In our case in non-reliable states the increased attention on the (mostly positive) survey feedback created by vividness exacerbates the difference in opinion leading to higher turnover. This effect impacts mostly buyers since the predominantly positive market sentiment confirms their priors more than the sellers. This would imply the following impact of vividly presented information on turnover and price levels:

**Hypothesis 4** (Price-volume hypothesis): Vividness elevates market sentiment exacerbating disagreement amongst sentiment driven traders, which during periods of positive market sentiment leads to both higher turnover and higher current returns.

In order to test our hypotheses, we introduce four indicator variables corresponding to the four possible reliability-presentation combinations:

- \( D_{nr,p} \) - Indicator variable for trading periods when non-reliable information is presented in a pallid way (non-reliable/pallid presentation).
- \( D_{nr,v} \) - Indicator variable for trading periods when non-reliable information is presented in a vivid way (non-reliable/ vivid presentation).
- \( D_{hr,p} \) - Indicator variable for trading periods when highly reliable information is presented in a pallid way (highly-reliable/ pallid presentation).
- \( D_{hr,v} \) - Indicator variable for trading periods when highly reliable information is presented in a vivid way (highly-reliable/ vivid presentation).

5. Results

Table 2 provides descriptive data of the trading sessions grouped by treatments. In columns 1 and 2 we display the number of traders that enter bids and asks respectively, which are measured relative to the total number of traders. Both of these reveal significant interest in trading with around 40% active bidders and around 35% active askers for both stocks. Column 3 shows the average volume per trader and Column 4 the volatility of the price returns. For both stocks the average volume per trader aggregated over all treatments is around 3. Column 5 shows the average portfolio returns for the traders from the various treatments. The average trader fails to reach the 4% risk free return.
rate (they are otherwise guaranteed on their cash holdings) in two of the treatments, with the return in the All Vivid treatment being the lowest.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Stock</th>
<th>Bidders</th>
<th>Askers</th>
<th>Volume per Trader</th>
<th>Volatility</th>
<th>Portfolio Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Pallid</td>
<td>N</td>
<td>0.428</td>
<td>0.325</td>
<td>2.730</td>
<td>0.117</td>
<td>0.041</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>0.438</td>
<td>0.269</td>
<td>2.681</td>
<td>0.161</td>
<td></td>
</tr>
<tr>
<td>All Vivid</td>
<td>N</td>
<td>0.413</td>
<td>0.379</td>
<td>2.839</td>
<td>0.110</td>
<td>0.027</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>0.353</td>
<td>0.359</td>
<td>3.12</td>
<td>0.100</td>
<td></td>
</tr>
<tr>
<td>Block Vivid</td>
<td>N</td>
<td>0.466</td>
<td>0.388</td>
<td>3.318</td>
<td>0.078</td>
<td>0.041</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>0.436</td>
<td>0.367</td>
<td>2.636</td>
<td>0.085</td>
<td></td>
</tr>
<tr>
<td>&gt; Vividness</td>
<td>N</td>
<td>0.484</td>
<td>0.337</td>
<td>3.18</td>
<td>0.217</td>
<td>0.063</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>0.431</td>
<td>0.307</td>
<td>3.42</td>
<td>0.090</td>
<td></td>
</tr>
<tr>
<td>&lt; Vividness</td>
<td>N</td>
<td>0.467</td>
<td>0.366</td>
<td>2.421</td>
<td>0.092</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>0.398</td>
<td>0.311</td>
<td>2.502</td>
<td>0.102</td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>N</td>
<td>0.431</td>
<td>0.365</td>
<td>2.977</td>
<td>0.135</td>
<td>0.037</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>0.398</td>
<td>0.337</td>
<td>2.89</td>
<td>0.108</td>
<td></td>
</tr>
</tbody>
</table>

The variables are measured as follows: In columns 1 and 2, Bidders (Askers) = \( \text{Average} \left( \frac{\text{No. of traders making bids (asks)}}{\text{No. of Traders}} \right) \); in column 3, Volume per Trader = \( \text{Average} \left( \frac{\text{Traded Volume}}{\text{No. of Traders}} \right) \); in column 4, Volatility is the per period standard deviation of price returns; in column 5, we have the average of each trader’s portfolio return.

We test the hypotheses developed in the previous section through two sets of variables: one set is based on the limit order book which is a collection of the individual traders’ limit prices and a direct measure of trading activity, while the second set involves the market variables and therefore more suitable for testing the more intricate biases.

5.1. Order Book Composition Measures

5.1.1. Attention Measures We construct three measures from the orders of individual traders that are able to directly measure the attention grabbing aspects of vividness in Hypothesis 1. Our measures are the size of the order book and its components, i.e. the number of bids and asks.
We label these as attention measures, since they are an indication of the interest to trade amongst subjects conditional on our information flow. They are defined as:

\[
\text{Order Book Size}_i = \frac{\text{Number of Bids} + \text{Number of Asks}}{\text{Number of Traders}} \\
\text{Number of Bids per Trader}_i = \frac{\text{Number of Bids}}{\text{Number of Traders}} \\
\text{Number of Asks per Trader}_i = \frac{\text{Number of Asks}}{\text{Number of Traders}}, \text{ where } i = N,X.
\]

The distributions for these measures are represented through box-and-whisker plots. They provide a visual summary of the first and the third quartile, the median and its 95% confidence interval (shaded grey area) as well as the tail characteristics of the distribution.

**Figure 6 Distribution of Order Book Size**

![Box-and-Whisker Plots](image)

(a) Vivid vs Pallid for Different Information States  
(b) Vivid vs Pallid for Negative and Positive Reliable States

Figure 6(a) compares the distribution of the order-book size between pallid and vivid states controlling for reliability. In addition for highly reliable states, we also display the data separately for positive and negative states in subfigure (b), since positive and negative information provides

\[\text{The box portion shows the middle 50 percent of the data through the first and third quartiles, where the difference between them represents the interquartile range (QR). The line through the center of the box denotes the median. The staples, which are the short vertical lines outside the box on both sides, indicate the last data points within (or equal to) the first quartile minus 1.5*QR and the third quartile plus 1.5*QR. Whiskers are the lines drawn from the sides of the box to the corresponding staple.}\]
Figure 7  Distribution of Bid Size

(a) Vivid vs Pallid for Different Information States  
(b) Vivid vs Pallid for Negative and Positive Reliable States

Figure 8  Distribution of Ask Size

(a) Vivid vs Pallid for Different Information States  
(b) Vivid vs Pallid for Negative and Positive Reliable States

a signal about the future dividend only in reliable states. The boxplots of our attention measures clearly validate the attention grabbing effect of vividness, as indicated by the strong impact of vivid information on interest to trade amongst subjects. Order book sizes increase when information is presented in a vivid fashion for both non-reliable and reliable states. Testing the difference
between the medians using the Mann-Whitney-Wilcoxon procedure, we find a significant increase in order book size for vivid presentation in both non-reliable (p=0.0002) and reliable (p=0.0003) information states.

When splitting up the order book to look at bid size and ask size separately, figures 7 and 8 respectively, we find that both the bid size and ask size increase when information is presented vividly. Vividness of information has a larger impact on ask size for non-reliable news, while for reliable news vividness creates a relatively larger impact on bid size. For order book size, we observe that vivid information skews the distribution to the right. Interestingly, this skewness to the right is much more pronounced for non-reliable states compared to reliable ones. This is primarily driven by the bid size.

Overall, in figures 6(a) - 8(a) we find that for all 18 composite measures, vividness creates a stronger impact. In figures 6(b) - 8(b), all except one amongst the 18 measures indicate a stronger impact for vivid presentation of information. In general both for positive and negative reliable states, vividness has a strong impact and the effect is relatively more pronounced for negative states. Testing for difference in medians we find that the impact of vividness in negative states is significant for all order book measures, while in positive states the impact is only significant for bid size.

The main observation here is that the increase in the size of the order book and its components as a consequence of vividness is attributable to the limited attention of investors. When information is presented in a vivid manner, attention as measured by the order book size will be elevated compared to when the information is presented in a pallid manner.

5.1.2. Variation Measures In hypothesis 2, we argued that when information is presented vividly, the order book displays a wider array of limit order prices leading to higher variances in bids and asks as well as greater disparity between average bids and asks. The relationship follows from the effects of vividly presented information to investors with limited attention who exhibit overconfidence and are heterogenous in their prior beliefs. We construct the average ask

\[
9 \text{ We compare each first, second (median) and third quartiles between pallid (P) and vivid (V) for reliable and non-reliable information separately, for each of the three order book measures.}
\]
and average bid price difference and the variance of individual bid and ask prices within each trading period as our variation measures.

\[
\bar{P}_{s,i} - \bar{P}_{b,i} = \frac{\text{Mean Ask} - \text{Mean Bid}}{\text{Predicted End Value}}
\]

Predicted End Value

\[
\text{Normalized Variance of Bids per trading period, } t = \frac{\text{Bid Variance}}{(\text{Median Bid})^2}
\]

\[
\text{Normalized Variance of Asks per Trading Period, } t = \frac{\text{Ask Variance}}{(\text{Median Ask})^2}, \text{ where } i = N,X.
\]

Our first measure \( \bar{P}_{s,i} - \bar{P}_{b,i} \) captures the difference between the average ask and bid prices. An intuitive interpretation of this measure is that it proxies for the divergence of opinion between our subjects. A smaller measure reflects more convergence of opinion between the buy and the sell side of the market. We find that all our quartile measures unequivocally demonstrate that vividness creates more divergence in expectations between the buy and the sell side of the market (see figure 9(a)). The Mann-Whitney-Wilcoxon test for differences in median between vivid and pallid presentation yields \( p\)-values of 0.004 and 0.003 for non-reliable and reliable information states respectively. This confirms hypothesis 2.

The same holds true for reliable information when split over positive and negative states (see figure 9(b)). Similar to our findings for order book size, the impact of vividness skews the distribution farther to the right for non-reliable states.

Another measure for difference in opinion is the variance within asks and bids. Figures [10] and [11] plot the distributions of the normalized variance of asks and bids across regimes.

We observe that the vivid presentation of information increases the variance of bids for both non-reliable and reliable states (see figure 11(a)). Testing for the difference in median variance between vivid and pallid presentation, we find that this increase is significant for non-reliable states (\( p\)-value = 0.005) and not for reliable states (\( p\)-value=0.33). This is again consistent with our hypothesis 2. For ask variance we do not detect any significant effect of vivid presentation both for non-reliable (\( p\)-value=0.33 for difference in median) and reliable (\( p\)-value=0.15 for difference in median) states (see figure 10(a)). The interquartile range for vivid states is wider for both bid and ask variances, though it is more pronounced for ask variances. Again, the impact of vividness skews the distribution of the variances further to the right for non-reliable states.
5.2. Regression Analysis

The previous discussion did not take into account possible effects from path-dependency. We therefore run regression tests which take into account the effect of the percentage change in the market price at the end of the previous period \((R_{t-1,N})\) and the percentage dividend change at the
end of the previous period ($\Delta DIV_{i-1}$). Note that $\Delta DIV_{i-1}$ is the most recent realized dividend information subjects have before trading. We test the effect of presentation/reliability combinations on selected dependant variables through the following regressions, where $D_{m}$ is a new indicator variable for trading periods when no information is provided.

\[
(P_b - P_s)_{i} = \beta_1 R_{t-1,i} + \beta_2 \Delta DIV_{i-1,i} + \beta_3 D_m + \beta_4 D_{nr} + \beta_5 D_{hr} + \mu_1
\]

\[
BookSize_i = \gamma_1 R_{t-1,i} + \gamma_2 \Delta DIV_{i-1,i} + \gamma_3 D_m + \gamma_4 D_{nr} + \gamma_5 D_{hr} + \mu_2
\]

\[
BidSize_i = \eta_1 R_{t-1,i} + \eta_2 \Delta DIV_{i-1,i} + \eta_3 D_m + \eta_4 D_{nr} + \eta_5 D_{hr} + \mu_3
\]

\[
AskSize_i = \theta_1 R_{t-1,i} + \theta_2 \Delta DIV_{i-1,i} + \theta_3 D_m + \theta_4 D_{nr} + \theta_5 D_{hr} + \mu_4
\]

for stock $i = \{N,X\}$

Table 3 displays the regression results for stock N. From column 1 we observe that for non-reliable information the average bid and average ask price difference significantly increases when information is presented in a vivid manner. The same holds for the difference between vivid and
pallid reliable information. The regressions confirm the earlier findings from the box plot distributions. The increase in the difference between average ask and average bid price both in the case of non-reliable and reliable information confirms hypothesis 2. The effect of vividness, as in the boxplots, seems stronger for non-reliable states compared to reliable ones.

Table 3  Regression Results for Order Book Composition Measures of Stock N

<table>
<thead>
<tr>
<th></th>
<th>$\bar{P}_b - \bar{P}_s$</th>
<th>Book Size</th>
<th>Bid Size</th>
<th>Ask Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Return$_{-1,N}$</td>
<td>-0.856**</td>
<td>-53.85***</td>
<td>-40.47**</td>
<td>-13.38***</td>
</tr>
<tr>
<td></td>
<td>(0.346)</td>
<td>(19.48)</td>
<td>(18.79)</td>
<td>(3.387)</td>
</tr>
<tr>
<td>ΔDividend$_{-1,N}$</td>
<td>-0.644***</td>
<td>2.655 (10.43)</td>
<td>8.818 (10.07)</td>
<td>-6.163***</td>
</tr>
<tr>
<td></td>
<td>(0.185)</td>
<td></td>
<td></td>
<td>(1.814)</td>
</tr>
<tr>
<td>D$<em>{hr,v} - D</em>{hr,p}$</td>
<td>0.393***</td>
<td>20.07***</td>
<td>18.43***</td>
<td>1.64 (1.149)</td>
</tr>
<tr>
<td></td>
<td>(0.117)</td>
<td>(6.607)</td>
<td>(6.376)</td>
<td></td>
</tr>
<tr>
<td>D$<em>{hr,v} - D</em>{hr,p}$</td>
<td>0.332***</td>
<td>19.33***</td>
<td>17.58***</td>
<td>1.758*</td>
</tr>
<tr>
<td></td>
<td>(0.114)</td>
<td>(6.437)</td>
<td>(6.211)</td>
<td>(1.119)</td>
</tr>
<tr>
<td>D$<em>{hr} - D</em>{nr}$</td>
<td>-0.171</td>
<td>3.5 (9.222)</td>
<td>3.424 (8.90)</td>
<td>0.076 (1.604)</td>
</tr>
<tr>
<td></td>
<td>(0.164)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>216</td>
<td>216</td>
<td>216</td>
<td>216</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.169</td>
<td>0.111</td>
<td>0.092</td>
<td>0.226</td>
</tr>
</tbody>
</table>

Winsorized data (at 5% level divided equally between both sides of the tail) was used for all dependant variables and Return$_{-1,N}$. Number inside parenthesis denotes std. error. Wald test is used for difference in coefficients. *** denotes significance at 1% level, ** denotes significance at 5% but not 1% level and * denotes significance at 10% but not 5% level.

Comparing the average bid and average ask price difference when there is a change in reliability, we see that there is a reduction in the difference when we move from a non-reliable to a reliable state. Therefore, reliability, as is to be expected, reduces the spread by resolving some of the uncertainty regarding future returns. However this change is not significant. Vividness, even after controlling for the last period dividend and market return, exhibits a significant effect on all the measures for the size of the book, although the effect on the ask size is less significant. This again confirms our results from the boxplots.

Both the boxplots and the regressions clearly demonstrate the impact of vividness on the subjects’ behavior. Vividness invites more interest in trading (confirming hypothesis 1) while the
prices at which subjects are willing to trade are further apart (hypothesis 2). This seems to confirm that vividness has an attention and a divergence of opinion effect. Furthermore, the effect of vividness is more pronounced in non-reliable states.

5.3. Market Measures

Hypotheses 3 and 4 relate vividness to market variables, specifically to the price and deviation of the price from its fundamental value and also the relationship with volume (hypothesis 4).

We therefore introduce return ($R_i$) as the proportionate change in the current period market price compared to the previous period price for stock $i$, the price-value ratio ($P/V$)$_i$, as an indication of mispricing and turnover ($\text{Turnover}_i$) as the product of the stock price and quantity traded normalized through expected redemption value for stock $i$. These variables are formally defined as follows:

\begin{align*}
R_{t,i} &= \frac{P_{t,i} - P_{t-1,i}}{P_{t-1,i}} \\
(P/V)_{t,i} &= \frac{P_{t,i}}{(ERV)_{t,i}} \\
\text{Turnover}_{t,i} &= \frac{P_{t,i} \times \text{Volume}_{t,i}}{ERV_{t,i}}
\end{align*}

where $P_{t,i}$ is the market price of stock $i$ in time period $t$ and $ERV_{t,i}$ is the expected redemption value in period $t$ for stock $i$.

The effect of presentation/reliability combinations is tested on the above dependant variables through the following regressions:

\begin{align*}
R_{t,i} &= \mu_1 R_{t-1,i} + \mu_2 \Delta \text{DIV}_{t-1,i} + \mu_3 D_{nn} + \mu_4 D_{nr,v} + \mu_5 D_{hr,v} + \mu_6 D_{hr,p} + \epsilon_5 \\
(P/V)_{t,i} &= \kappa_1 R_{t-1,i} + \kappa_2 \Delta \text{DIV}_{t-1,i} + \kappa_3 (P/V)_i + \kappa_4 D_{nn} + \kappa_5 D_{nr,v} + \kappa_6 D_{hr,v} + \kappa_7 D_{hr,p} + \epsilon_6 \\
\text{Turnover}_{t,i} &= \upsilon_1 \text{Turnover}_{t-1,i} + \upsilon_2 D_{nn} + \upsilon_3 D_{nr,v} + \upsilon_4 D_{hr,v} + \upsilon_5 D_{hr,p} + \upsilon_6 D_{nr,p} + \epsilon_7
\end{align*}

for stock $i = \{N,X\}$.

Table 4 displays the regression results for stock N. The variable $R_{t-1,N}$ as defined before denotes the percentage change in the market price at the end of the previous period, while $\Delta \text{DIV}_{t-1}$ denotes...
the percentage dividend change at the end of the previous period. Note when information is reliable, we need to take into account the direction of the dividend information (positive or negative) to assess the impact on price changes. Hence for both returns and price-value ratios we look at the differences between states with positive and negative reliable information in order to assess the impact of vividness. Therefore, we introduce two additional regime based indicator variables, $D_{hr,j}^+$ and $D_{hr,j}^-$, which represent periods with statistically reliable positive and negative information respectively ($j$ denotes vivid or pallid presentation of information).

Table 4  Regression Results for Market Measures of Stock N

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>$\text{Return}_{t,N}$</th>
<th>$\text{Price-Value Ratio}_{t,N}$</th>
<th>$\text{Turnover}_{t,N}$ (in 1000s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>$\text{Return}_{t-1,N}$</td>
<td>0.255*** (0.059)</td>
<td>0.328 (0.319)</td>
<td>–</td>
</tr>
<tr>
<td>$\Delta \text{Dividend}_{t-1,N}$</td>
<td>0.245*** (0.031)</td>
<td>0.185 (0.179)</td>
<td>–</td>
</tr>
<tr>
<td>$\text{Price-Value Ratio}_{t-1,N}$</td>
<td>–</td>
<td>0.902*** (0.036)</td>
<td>–</td>
</tr>
<tr>
<td>$\text{Turnover}_{t-1,N}$</td>
<td>–</td>
<td>–</td>
<td>0.632*** (0.053)</td>
</tr>
<tr>
<td>$D_{nr,v} - D_{nr,p}$</td>
<td>0.034* (0.020)</td>
<td>0.095 (0.106)</td>
<td>14.05** (7.284)</td>
</tr>
<tr>
<td>$D_{hr,v} - D_{hr,p}$</td>
<td>–</td>
<td>–</td>
<td>-0.085 (6.951)</td>
</tr>
<tr>
<td>$D_{hr} - D_{nr}$</td>
<td>–</td>
<td>–</td>
<td>15.05 (10.20)</td>
</tr>
<tr>
<td>$D_{hr,v}^+ - D_{hr,p}$</td>
<td>0.045* (0.027)</td>
<td>-0.289** (0.143)</td>
<td>–</td>
</tr>
<tr>
<td>$D_{hr,v}^- - D_{hr,v}^-$</td>
<td>0.063** (0.028)</td>
<td>-0.327** (0.151)</td>
<td>–</td>
</tr>
<tr>
<td>Observations</td>
<td>216</td>
<td>216</td>
<td>228</td>
</tr>
<tr>
<td>R$^2$</td>
<td>0.372</td>
<td>0.806</td>
<td>0.409</td>
</tr>
</tbody>
</table>

Winsorized data (at 5% level divided equally between both sides of the tail) was used for all dependent and their respective lagged variables. Number inside parenthesis denotes std. error. Wald test is used for difference in coefficients. *** denotes significance at 1% level, ** denotes significance at 5% but not 1% level and * denotes significance at 10% but not 5% level.

For non-reliable states, we find that the impact on returns when the information is presented
vividly is significantly stronger than when the information is displayed pallidly (see column 1 in table 4). The vivid portrayal of non-reliable information distracts traders from relevant distributional information due to their limited attention. This over-reaction to vivid non-reliable information confirms our hypothesis 3a (investor distraction hypothesis).

For reliable states we find, as expected, returns are larger when positive information is available compared to negative information. For vivid information the difference in returns between positive and negative states is around 6.3% while for pallid information this difference is 4.5% (see column 1). Hence we observe a higher, albeit not significant, reaction to vivid compared to pallid reliable information. Column 2 indicates that the price-value ratio drops when reliable information is available. As prices in general are being pushed up during non-reliable states, the fall in the price-value ratio during reliable information states indicates subjects correctly reacting to the reliable information. We expect investors to better update their priors when the reliable information is presented in a vivid manner and hence, to observe stronger price correction. Indeed, we find the price correction to be larger (but not significantly so) when the reliable information is vivid (-0.289 for pallid and -0.327 for vivid presentation from column 2). Both the higher difference in returns and the stronger price correction for vivid versus pallid presentation provides evidence that is consistent with hypothesis 3b (investor focus hypothesis), i.e. vivid portrayal of reliable information alleviates limited attention of investors.

Our final hypothesis (hypothesis 4) posits that vividness exacerbates disagreement which leads to higher turnover and higher current returns, which Hong and Stein (2007) attribute to market sentiment. In our case, the survey feedback reflects market sentiment which then gets reinforced through vividness of presentation in non-reliable states. The predominantly positive market sentiment in non-reliable states coincides with significant increases in differences in variances in bidders prices between vivid and pallid presentation. This provides an explanation for the significant increase in both returns and turnover we observe in table 4 with vivid presentation in non-reliable states, which is consistent with hypothesis 4.

10 From the survey we observed that subjects are on average optimistic about changes in value (more than 90% of trading periods had a majority of subjects, 67% on average, choose the positive outcome).
5.4. Treatment Effects

In order to examine the robustness of the impact of vividness, we look at the data from each of the treatments separately. We observe from figures [12] [13] and [14] that the attention that vividness creates does not diminish with successive recurrences. Evidence of the stability of this effect can be seen from the All Vivid treatment which has the highest quartile values compared to all other treatments. Vivid information within the Block Vivid treatment generates higher interest and variation for all measures compared to information presented in a pallid form. The effect is also present in the more diffused vividness treatments (> Vividness and < Vividness) but is less pronounced.

Figure 12  Distribution of Order Book Measures across Treatments

(a) Average Bid and Average Ask Price Difference  
(b) Order Book Size

5.5. Spillover Effects

The information flows in our set-up only contained information on stock N. By exploring the effect of information flows on stock X, we try to ascertain whether such information flows have any spillover effects on decisions regarding stock X. Therefore, we regress orderbook and market measures of stock X as indicated in equations [1a] [10] and equations [2a] [2c]. The results for the regressions are displayed in tables [5] and [6].
We should not expect any effect of information for stock N on stock X trading decisions, since all information flows are regarding future returns of stock N by design. However, we observe from table significant effects of vividness in information flows related to stock N on order book variables for stock X. We interpret this as a spillover of attention effect of vividness, where vivid

\[\text{equation}\]
Table 5  Regression Results for Order Book Composition Measures of Stock X

<table>
<thead>
<tr>
<th></th>
<th>Stock X</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>( \bar{P}_b - \bar{P}_s )</td>
<td></td>
</tr>
<tr>
<td>Return(_{t-1},X)</td>
<td>0.18    (0.141)</td>
</tr>
<tr>
<td>( \Delta \text{Dividend}_{t-1},X )</td>
<td>-0.643** (0.253)</td>
</tr>
<tr>
<td>( D_{hr,s} - D_{hr,p} )</td>
<td>-0.134* (0.08)</td>
</tr>
<tr>
<td>( D_{hr,s} - D_{nr,p} )</td>
<td>0.184** (0.077)</td>
</tr>
<tr>
<td>( D_{hr} - D_{nr} )</td>
<td>0.204* (0.11)</td>
</tr>
<tr>
<td>Observations</td>
<td>216</td>
</tr>
<tr>
<td>R(^2)</td>
<td>0.085</td>
</tr>
</tbody>
</table>

Winsorized data (at 5% level divided equally between both sides of the tail) was used for all dependant variables and Return\(_{t-1},X\). Number inside parenthesis denotes std. error. Wald test is used for difference in coefficients. *** denotes significance at 1% level, ** denotes significance at 5% but not 1% level and * denotes significance at 10% but not 5% level.

A vivid presentation of stock N information creates attention beyond trading of just stock N (i.e. spillover effect of hypothesis 1). Since the information flow is related to stock N only, we would not expect any effects on returns of stock X. As observed from table 6, we do not find any impact of vividness on returns for stock X.

5.6. Effect of Dividend Patterns

Finally, we examine the impact of the past pattern of realized dividends on market returns. We identify variables based on the sequence of changes in dividends, both negative and positive and whether the sequence of changes are short-run or long-run phenomena. We assess this by defining two sets of variables. The first set of variables denote the length of a dividend series and are defined as follows:

\[ \text{NegLR}_{t,N} \] — Variable indicating the number of consecutive periods for stock N, where the dividend change has been negative.

\[ \text{PosLR}_{t,N} \] — Variable indicating the number of consecutive periods for stock N,
Table 6  Regression Results for Market Measures of Stock X

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Return$_t$,X</th>
<th>Price-Value Ratio$_t$,X</th>
<th>Turnover$_t$,X (in 1000s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return$_t−1$,X</td>
<td>-0.121* (0.069)</td>
<td>0.154 (0.1)</td>
<td>—</td>
</tr>
<tr>
<td>ΔDividend$_t−1$,X</td>
<td>0.270** (0.125)</td>
<td>0.095 (0.189)</td>
<td>—</td>
</tr>
<tr>
<td>Price-Value Ratio$_t$,X</td>
<td>—</td>
<td>0.797*** (0.047)</td>
<td>—</td>
</tr>
<tr>
<td>Turnover$_t−1$,X</td>
<td>—</td>
<td>—</td>
<td>0.020 (0.069)</td>
</tr>
<tr>
<td>$D_{hr,v}−D_{hr,p}$</td>
<td>0.042 (0.039)</td>
<td>0.053 (0.055)</td>
<td>10.03*** (3.94)</td>
</tr>
<tr>
<td>$D_{hr,v}−D_{hr,p}$</td>
<td>—</td>
<td>—</td>
<td>-0.878 (3.77)</td>
</tr>
<tr>
<td>$D_{hv}−D_{hr}$</td>
<td>—</td>
<td>—</td>
<td>-3.089 (5.473)</td>
</tr>
<tr>
<td>$D_{hv}^+−D_{hv,p}$</td>
<td>-0.005 (0.052)</td>
<td>-0.023 (0.1073)</td>
<td>—</td>
</tr>
<tr>
<td>$D_{hv}^+−D_{hv,v}$</td>
<td>0.037 (0.055)</td>
<td>0.027 (0.077)</td>
<td>—</td>
</tr>
<tr>
<td>Observations</td>
<td>216</td>
<td>216</td>
<td>228</td>
</tr>
<tr>
<td>R$^2$</td>
<td>0.051</td>
<td>0.646</td>
<td>0.043</td>
</tr>
</tbody>
</table>

Winsorized data (at 5% level divided equally between both sides of the tail) was used for all dependant and their respective lagged variables. Number inside parenthesis denotes std. error. Wald test is used for difference in coefficients. *** denotes significance at 1% level, ** denotes significance at 5% but not 1% level and * denotes significance at 10% but not 5% level.

For our second set of variables that capture the pattern of dividend changes, we choose indicator variables for the length of the series. They are defined as follows:

DDivRun_Neg2$_t$,N  — Indicator variable for trading periods when the pattern of dividend changes for stock N has been negative for exactly 2 consecutive periods.

DDivRun_Neg3$_t$,N  — Indicator variable for trading periods when the pattern of dividend changes for stock N has been negative for exactly 3 consecutive periods.

DDivRun_Neg4$_t$,N  — Indicator variable for trading periods when the pattern of dividend changes for stock N has been negative for 4 or more consecutive periods.

The variables for positive runs, i.e. DDivRun_Pos2$_t$,N, DDivRun_Pos3$_t$,N and DDivRun_Pos4$_t$,N, are defined in a similar fashion.
Based on our indicator variables we construct the following regression equations:

\[ R_{t,N} = \phi_1 R_{t-1,N} + \phi_2 \text{NegLR}_{t,N} + \phi_3 \text{PosLR}_{t,N} + \varepsilon_8 \]  

(3)

\[ R_{t,N} = \gamma_1 R_{t-1,N} + \gamma_1 \text{DDivRun}_\text{Neg}2_{t,N} + \gamma_1 \text{DDivRun}_\text{Neg}3_{t,N} + \gamma_1 \text{DDivRun}_\text{Neg}4_{t,N} + \gamma_5 \text{DDivRun}_\text{Pos}2_{t,N} + \gamma_6 \text{DDivRun}_\text{Pos}3_{t,N} + \gamma_7 \text{DDivRun}_\text{Pos}4_{t,N} + \varepsilon_9 \]  

(4)

Table 7 Regression Results for Effect of Dividend Patterns on Stock N

<table>
<thead>
<tr>
<th></th>
<th>(a) Reliable Information Regimes</th>
<th></th>
<th>(b) Non-Reliable Information Regimes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Return(_{t,N})</td>
<td>Return(_{t-1,N})</td>
<td>Return(_{t-1,N})</td>
<td>Return(_{t-1,N})</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.018*</td>
<td>-0.019*</td>
<td>Constant</td>
<td>-0.041***</td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.011)</td>
<td></td>
<td>(0.012)</td>
</tr>
<tr>
<td>Return(_{t-1,N})</td>
<td>0.268***</td>
<td>0.318***</td>
<td>Return(_{t-1,N})</td>
<td>0.203**</td>
</tr>
<tr>
<td></td>
<td>(0.091)</td>
<td>(0.088)</td>
<td></td>
<td>(0.084)</td>
</tr>
<tr>
<td>NegLR(_{t,N})</td>
<td>-0.015*</td>
<td>–</td>
<td>NegLR(_{t-1,N})</td>
<td>-0.003</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td></td>
<td></td>
<td>(0.008)</td>
</tr>
<tr>
<td>PosLR(_{t,N})</td>
<td>0.024***</td>
<td>–</td>
<td>PosLR(_{t-1,N})</td>
<td>0.065***</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td></td>
<td></td>
<td>(0.016)</td>
</tr>
<tr>
<td>DDivRun_\text{Neg}2(_{t,N})</td>
<td>–</td>
<td>-0.037</td>
<td>DDivRun_\text{Neg}2(_{t-1,N})</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.024)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DDivRun_\text{Neg}3(_{t,N})</td>
<td>–</td>
<td>-0.074***</td>
<td>DDivRun_\text{Neg}3(_{t-1,N})</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.029)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DDivRun_\text{Neg}4(_{t,N})</td>
<td>–</td>
<td>0.009</td>
<td>DDivRun_\text{Neg}4(_{t-1,N})</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.034)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DDivRun_\text{Pos}2(_{t,N})</td>
<td>–</td>
<td>0.068**</td>
<td>DDivRun_\text{Pos}2(_{t-1,N})</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.026)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DDivRun_\text{Pos}3(_{t,N})</td>
<td>–</td>
<td>0.077**</td>
<td>DDivRun_\text{Pos}3(_{t-1,N})</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.029)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DDivRun_\text{Pos}4(_{t,N})</td>
<td>–</td>
<td>0.081***</td>
<td>DDivRun_\text{Pos}4(_{t-1,N})</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.024)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>90</td>
<td>90</td>
<td>Observations</td>
<td>126</td>
</tr>
<tr>
<td>R(^2)</td>
<td>0.397</td>
<td>0.453</td>
<td>R(^2)</td>
<td>0.208</td>
</tr>
</tbody>
</table>

Winsorized data (at 5% level divided equally between both sides of the tail) was used for all dependant variables and Return\(_{t-1,N}\). Number inside parenthesis denotes std. error. *** denotes significance at 1% level, ** denotes significance at 5% but not 1% level and * denotes significance at 10% but not 5% level.
We observe from tables 7(a) and 7(b) that market returns become more pronounced the longer the persistence of the dividend direction in consecutive periods. This effect on returns is especially pronounced for information that indicates an increase in dividend. We find this to be true for reliable news where we include the information of the current news item in determining the pattern, as well as for non-reliable news where we determine the pattern up to the previous period.

6. Conclusions

Our findings suggest that vividness elevates attention levels of investors leading to larger order book sizes and greater divergence of opinion amongst investors with heterogeneous priors. We find that the implications of this attention-grabbing effect of vividness on market variables depends upon the nature of the information content. When the information is non-reliable, vivid presentation distracts from the relevant creating significantly higher levels of mispricing. In contrast, when information is reliable, vivid presentation enables investors to focus more on the relevant, leading to better price correction. However, there are subtler effects which have interesting implications. Information when presented vividly, has a stronger and broader effect when it is non-reliable. In non-reliable states, information reflects the sentiments of the investors. Therefore, when the information in such states is presented vividly, on average it has a pronounced prior-confirming effect. In the presence of overconfident investors, this translates into larger overreaction, suggesting in general that vividness amplifies the effect of underlying investor biases. In reliable information states, the prior-confirmation effect occurs less frequently therefore limiting the impact of the overconfidence bias.

Further, we find that during periods of vividly presented non-reliable information, which we argue are periods when levels of market sentiment get elevated, greater mispricing is also accompanied by higher turnover. This suggests that the vivid presentation of information plays a critical role not only in elevating market sentiment, but also by triggering the effects of underlying biases creates an impact which perpetuates itself in the long-run.

We also find that market returns are influenced by the pattern of dividend changes. Market reactions are stronger the longer the sequence of dividends in one direction. This holds especially
for positive changes in dividend. Finally, we also find spill-over effects of vividness on other stocks.

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References


