

# The same yet different: the effects of vividness in a laboratory asset market\*

Sudeep Ghosh<sup>†</sup> and Tom Vinaimont<sup>‡</sup>

**Abstract:** We provide a framework to interpret investor reactions to qualitatively augmented financial data. Information providers use vivid qualifiers to make base-rate information proximate, emotionally engaging and imagery-producing. Vivid treatment patterns influence investor behavior through biases triggered by the activation of attention and focus. In our laboratory asset market, we expose subjects to information derived from two sources: directional content from a system source and constructed content from a social feedback mechanism. Effects of treating the information with vivid attributes are measurable and strong. Individual responses to vivid information indicate more attention and engagement, resulting in more willingness to trade. Such responses transcend the market clearing mechanism to also affect market variables. System-generated high quality information content creates more focus and adjusts prices towards fundamental values. Low quality information content from a social source distracts participants by confirming their prior optimism bias, leading to larger price deviations from fundamental values. Further, when information from the social source is portrayed vividly, it moderates the interaction between information and sentiment resulting in trade flows from pessimists to optimists. Overall, treatments with more vivid displays tend to sustain prices above fundamental values.

**Keywords:** Vividness, Financial Information, Trading Behavior, Experiment.

**JEL-codes:** C91, C92, G41

---

\*The authors thanks the Hong Kong Polytechnic University for IRG funding and CityU of Hong Kong for SRG funding of this project. We thank Onn Mah for providing assistance in programming and seminar participants at KULeuven, University of Texas (Dallas), Hong Kong Polytechnic University, University of Vaasa and Nazarbayev University for comments. All remaining errors are the authors'.

<sup>†</sup>School of Accounting and Finance, The Hong Kong Polytechnic University, Li Ka Shing Tower, Hung Hom, Hong Kong SAR, email:sudeep.ghosh@polyu.edu.hk (ORCID ID: 0000-0003-4160-978X).

<sup>‡</sup>Graduate School of Business, Nazarbayev University, Qabanbay Batyr 53, 010000 Nur-Sultan, Republic of Kazakhstan; email:tom.vinaimont@nu.edu.kz (ORCID ID: 0000-0003-1582-7775).

## **Declarations**

### **Funding**

We acknowledge financial support from the Hong Kong Polytechnic University (IRG funding) and from the City University of Hong Kong (SRG funding) for this project.

### **Conflicts of interest/Competing interests**

none

### **Availability of data and material**

Data collected for this study will be provided by the authors during the review process on request and can be made available for download upon acceptance.

### **Code availability**

Code used in this study is available upon request.

### **Ethics Approval**

The data we examine for this text is generated from experiments on human subjects. We followed institutional guidelines and received approval and consent from institutional (City University of Hong Kong) and grant committees (Strategic Research Grant) after submitting the grant proposal detailing the experiment.

### **Consent to Participate**

Subjects voluntarily applied, freely registered to participate in the experiment sessions and consented to take part in this study.

### **Consent for publication**

No identifiable personal data was gathered during the experiments.

# 1 Introduction

Participants in financial markets deconstruct content from various news sources into signals in search for informative components to assist decision making. Their own expectations are then shaped by melding this information with their beliefs. Content producers convert a variety of private and publicly-available components into formats that entice and engage participants into accessing the information they seek. These formats, in turn, can influence how participants interpret the information components. We use a controlled experiment to demonstrate the impact of the information dissemination process on individuals' behavior. We also examine how this affects aggregate market measures. Our findings complement a growing number of studies that add qualitative aspects to the traditional quantitative analysis of financial data.

In our study, information generated from two distinct sources, system and social, are transformed into news content and presented to participants who interact in an experimental asset market. System content consists of a directed flow of information pulses about future cash flows, while social content is constructed by collecting feedback responses from the participants during the experiment.

In our setting, we design treatments to influence the attention participants exhibit by switching information carriers from non-vivid to vivid modes and vice versa. The concept of vividness is based on an idea introduced in the psychology literature: we coin information carriers as being in the vivid mode if attributes turn the information they portray more proximate, emotionally engaging and imagery producing. We expose both system content and social content to activation of this vivid mode. The purpose of the experiment in this paper is twofold. At a behavioral level we examine the impact of vivid attributes on trading and how these transcend the market mechanisms. From a broader societal perspective, we identify what stimulates individuals towards meaningful societal interactions through market environments and suggest how media, both traditional and machine learning, assist this process. Specifically, we evaluate individuals' behavioral responses to vivid portrayals as well as their effect on aggregate measures through a market clearing process.

We organize the paper as follows: Section 2 introduces vividness and the method used to render information vivid. Section 3 provides the experimental design. Section 4 describes the channels through which vivid information solicits reaction and develops the hypotheses. In Section 5 we test the hypotheses and present our findings. Section 6 contains a discussion with further results. Finally we conclude.

## 2 Vividness

Our work is built on a construct best described as vividness. In psychology, displays of information are called vivid if they are more proximate, emotionally en-

gaging and imagery producing (Nisbett and Ross, 1980). In social psychology, vividness sometimes refers to the ease and conviction with which something is recalled in memory. Vividness is often mentioned alongside saliency and availability as being able to draw attention. However, the *modi operandi* of the latter are different. Saliency originates from attribution, availability from probability and vividness from persuasion. The three concepts reinforce each other in capturing attention and are essential in story building. They overlap partially and can be hard to disentangle in practice outside their theoretical construct. Yet, for our purpose it is important to point out certain crucial differences.

Salient information, through elements of surprise, rarity and contrast, appears newsworthy and ends up assigning higher weights to the information in the attribution process in comparison to less salient information. The context in which the information is placed and the resulting contrast are essential in turning this salient information noteworthy. The neuroscience literature (see e.g Melloni, van Leeuwen, Alink and Müller, 2012) categorizes this resulting form of attention as a bottom-up process.

Vivid information, on the other hand, draws attention through an autonomous story-building process without the need for context-induced contrast typical of saliency. Consumer behavior makes a clear distinction between vividness and saliency: salient information draws attention from all participants *some of the time*, while vividness draws attention from some participants *all of the time* (Kardes, Cronley and Cline, 2011). As part of the original literature on vividness, Kenamer (1988) suggests that vividness of information is a prime determinant of its newsworthiness. Damasio (1994) categorizes vivid descriptions of future outcomes as an important determinant of the corresponding emotional reactions<sup>1</sup>. Collins, Taylor, Wood and Thompson (1988) examine whether vivid messages are more persuasive due to their attention generating abilities. Clark and Rutter (1985) find that vivid information increases people’s confidence in their own opinions. Some of the original literature does not report strong evidence that vividness fully persuades individuals despite the widespread practical use of concept in marketing and communication. Collins et al. (1988) suggest vividness merely creates attracts interest and therefore engages rather than persuades. They also find that people tend to think others are more easily influenced by vividness than themselves. In a financial context, persuasion tends to imply a form of manipulation. Our approach in examining the effect of vividness is mostly centered on the engagement factor and on the tendency for individuals to anticipate that vividness influences others in their decision making. This line of thought brings vividness to the forefront as a tool that engages and interacts with sentiment without directly manipulating market participants through persuasion.

---

<sup>1</sup>Numerous other studies support findings that say statistical, base-rate and abstract information are underweighted compared to cases, scenarios and examples (see e.g. Tversky and Kahneman (1973), Borgida and Nisbett (1977), Reyes, Thompson and Bower (1980), Bar-Hillel (1980) and Bar-Hillel and Fischhof (1981).

Lastly, the availability heuristic is known to influence attention by linking immediate current examples to previous memories or experiences when subjects are faced with a decision.

Over time, the three concepts (saliency, vividness and availability) overlap: the strength of the individual and consecutive reactions to a series of vivid displays is likely to be influenced partly by availability and saliency<sup>2</sup>.

In this study, we expose participants in a controlled laboratory environment to vivid and non-vivid forms of financial information. The variation in vividness reflects the difference between compact financial streams such as headlines and concise expository announcements on a variety of financial information platforms. To avoid primary effects from saliency and availability to dominate, we display each arrival of information in isolation for a fixed time and employ specific templates for the vivid and non-vivid modes. Thus, we draw general attention first to the treated information. The information then integrates with the context. Arguably, this makes the reactions to differences between the treatments less susceptible to noise or confounding effects and turns saliency and availability auxiliary to the vividness treatment.

In our design, two instruments generate cash flows through two random generators with known distributional properties. For one of these instruments, termed the information carrier, system or social information is shared in vivid or non-vivid modes through a dissemination process. For the companion instrument no such additional information is disclosed. A third random generator determines whether the source of the distributed information is system or social. The elevated information-level of the system source more accurately reveals the future direction of the cash flow by unveiling the state of the generator prior to the draw. Content from the social source contains less accurate information on the future cash flow of the instrument. Through the feedback loop, however, social content may contain views which are not captured by aggregate market measures.

Within a financial market context, the information stream based on the system source can be seen as generating information predicted by analysts<sup>3</sup>. The social source is not unlike alternative sources for market-sentiment based on surveys (Brown and Cliff (2005), Lemon and Portniaguina (2006) and Qiu and Welch (2006)). By capturing and treating information originating from the survey, we avoid direct use of aggregate market measures in the feedback information stream. Hence, direct information from aggregate market measures are kept outside our feedback loop. We heed caveats (see e.g. Da, Engelberg and Gao, 2015) that

---

<sup>2</sup>The concept of vividness can also be put in a larger context: vivid perception can be triggered by external factors as in this work, but also through internal learning processes or through conditioning.

<sup>3</sup>Hirshleifer, Lim and Teoh (2009) are at the root of related literature on corporate announcements and attention. Michaely, Rubin and Vedrashko (2016) study competing stimuli and timing of announcements, and Israeli, Kasznik and Srishasan (2020) examine how unexpected distractions affect investors' decisions related to corporate announcements

participants might not answer survey questions truthfully, albeit for a different reason: spurious feedback. To alleviate this concern, we employ daemons<sup>4</sup> to monitor and validate some of the survey input to ensure a minimal degree of informativeness.

To yield the information flow from the carrier vivid, we activate three components: imagination, emotional engagement and proximity. To spark imagination, we add verbosity to map suggestive context to the source of the information. Emotionally engaging qualifiers<sup>5</sup> enhance the more authoritative tone of the system source and the feedback features from the social source. Context proximity is introduced by adding contextual terms that imply differences in levels of informativeness between the system and social source. We also increase font size, add a caption in red color and emphasize the font, all towards making the text appear physically proximate<sup>6</sup>.

### 3 Test Design and Experimental Setup

In our laboratory asset market<sup>7</sup>, participants are assigned the role of traders. We draw volunteers from a pool of business majors. Participants are paid a show-up fee and an amount in local currency that depends on their decisions and the decisions of others during the experiment session. On average we pay participants double the hourly rate they earn for routine jobs on campus. In total, we had 240 participants in 6 sessions of around 40 participants each.

Each participant receives 25,000 experimental currency units ( $E_\chi CUs$ ) and 250 shares each of two tradeable cash-flow generating instruments denominated in  $E_\chi CUs$ . Each treatment has twenty trading periods. There are two treatments per session. At the end of each treatment, participants receive their final portfolio values (in  $E_\chi CUs$ ) derived from trading gains and losses, capital gains and losses, income flows and cash holdings. At the end of the session, the  $E_\chi CUs$  from both treatments are added up and converted into cash at a determined exchange

---

<sup>4</sup>A daemon is a process that runs unobtrusively in the background

<sup>5</sup>Tetlock, Saar-Tsechansky and Mackassy (2008) count negative words in corporate news announcements and find brief underreactions to negative news. Solomon (2012) examines the role of investor relations firms in 'spinning' press releases and finds more media coverage by such firms of positive versus negative releases.

<sup>6</sup>To validate that our transformation from non-vivid to vivid states leads to elevated attention, we collected separate feedback before the experimental sessions on the perception of the texts. We recruited subjects separate from the participants in the experimental sessions to read the texts in vivid and non-vivid modes and provide feedback. Their comments clearly indicated that the vivid mode created more attention.

<sup>7</sup>This work is the first in a series of laboratory experiments we plan with the vivid factor as main treatment variable. We keep the design minimal, yet intricate enough to comply with nested future experiments. Some components, such as a blind session, fit that purpose. The main feature we discuss in this text is the introduction of vivid information flows.

rate<sup>8</sup>. Participants indicate willingness to trade by entering bids or asks, or both: a quantity and a maximum bid price if they wish to increase holdings, and a quantity and a minimum ask price if they wish to decrease holdings. Each period, the trading platform sets the market price through a limit order process by maximizing the traded volume based on bids and asks. After each market clearing, participants are informed of their order execution result, the cash flows from their holdings and the prevailing market price and volume.  $E_\chi CU$ s not invested accrue at a nominal interest rate known to the participants. The participants can view the history of all cash flows and aggregate market variables on an interactive dashboard<sup>9</sup>. They also see a summary of their portfolio comprising their holdings, including  $E_\chi CU$ s not invested, the history of their successful trades and the total cash flows earned till that period.

Two binomial random generators determine cash flows for the twenty consecutive periods in a treatment. The random generator process serves multiple purposes beyond just the determination of cash flows. The vivid switch and polarity in base-rate information are built on the cash flow structure, and the redemption value of the instrument at the end of the trading session is fixed as a theoretical perpetuity of the final cash flow. We refresh a projection of this expected perpetuity (the slipstream) after each cash flow change to serve as a guideline towards the conversion of the instruments to  $E_\chi CU$  at the end of the treatment. To support the decision making process, participants are further given a binomial dividend path tree for each of the instruments, a calculator and access to interactive charts detailing the evolution of price and volume variables from the market clearing process.

The two sources that provide information to the participants are different from multiple perspectives. Information from the system source is more precise about the flow generated by the instruments compared to information from the social source. The system source maps the information to reflect the binomial structure of the cash flow, while the social source maps the information collected from the subject feedback. Information from the system source is independent of participants' actions and only available at some specific trading periods. Information from the social source is made available every trading period in order to keep the

---

<sup>8</sup>The alternative is to have the participants pay-to-play or to enter through their own endowment which would be converted into and out of  $E_\chi CU$ s upon entry and exit, respectively. This would take care of the house-money or wind-fall gain effect. However, pay-to-play would be challenging to implement and would also add external framing thereby confounding results.

<sup>9</sup>Three instruments are embedded in the market information display that indicate current price changes, target price deviations and the market clearing intensity. Transformation to new market variables is displayed through a full screen update following the active input period. The basic display shows the most recent status of the variables. By pressing buttons participants can visualize the trajectories of historical market variables generated during their participating session. Access to historical data shows market prices and market turnovers.

feedback loop activated throughout the trading sessions.

Next, we describe how the vivid mode for displaying information vividly is activated. We keep vividness treatments minimal and textual to conform with the industry standard: we enhance textual formatting and enrich base-rate information with qualifiers and intensifiers<sup>10</sup>.

### 3.1 System information

The system reveals whether the upcoming cash flow is likely to be higher or lower than the current observed flow and reflects the state of a binomial tree (see the binomial tree in the Appendix A and B)

This information from the system source is displayed in either *muted* mode or in *vivid* mode depending on the activation of the vivid switch.

In muted mode the message displayed reads

Analysts' forecast of the next expected dividend payout for < *name and ticker* > is \$ < *number* >

In vivid mode the message displayed reads <sup>11</sup>

**NEWSFLASH: Independent analysts from major financial institutions forecast a strong performance by < *company name and ticker* >. The {*optimism; pessimism*} of analysts is driven by a {*surge; crash*} in orders for the company's products. Moreover, the analysts' opinion is reinforced by the {*solid; gloomy*} financial condition of the company. All analysts unanimously agree on the {*positive; negative*} outlook for <company name> and predict the next dividend to rise to \$ < *number* >**

---

<sup>10</sup>Adding qualifiers to base information pitches direction, while intensifiers deepen emotions. To construct the display texts for both sources we accessed the Lexis-Nexis database and scanned company news reports. We classified news reports on the basis of keywords, distinguishing company announcements from analyst-styled reports and texts based on interpretations. We identified that expected performance of companies is commonly rationalized or motivated by either information about the company's product market or financial position, or both. Although we implemented an automated extractor, we decided ultimately to craft the news report manually to better match the context of our experiment. That is, we created two sets of reports loosely based on the experiences we gained from the Lexis-Nexis database, but without most of the finer details to match the more rudimentary interface in our experiment. Our vivid display text draws on these characteristics of corporate news reports.

<sup>11</sup>The header 'newsflash' was displayed in red color.

We deliberately use the terms *analyst* and *independent* to indicate the information's connection to a system source. The words *forecast* and *unanimous* insinuate that the estimate and direction are stemming from a source whose information is independent of participants' beliefs.

## 3.2 Social information

Between trading rounds, participants' beliefs are solicited on the direction of the cash flow during the next period. None of the participants have prior knowledge of the actual outcome of the cash flow. However, each period, daemons choose three participants randomly and have their survey choices, unknown to them, deliberately amended to reflect the true outcome. Through this arrangement, the social feedback information contains some, albeit small and noisy, information on the cash flow. The size of the sample the daemons act upon is especially kept low to contrast the lower accuracy of this message with that of the system source. Participants might still value the information as the survey inputs could be related to sentiment-driven market price movements. All participants are made aware of the daemon arrangement. Each period, the results of the survey are shared with the participants.

The intensity of the daemons in our experiment closely matches the size of the observed error in participants' guesses. Participants guessed the state 48.6% on average. After altering the choice of 3 participants, 52% guesses on average represent the true state. Overall, 69.2% of participants on average indicate they expect a positive state which get displayed as 67.8% on average because of the daemon activity. In addition to providing direction, the daemons serve to ensure that information in the feedback is not completely spurious. Daemons also prevent extreme rational group behavior such as rationally coordinated guesses to infer future states with certainty. We do not find any evidence of such coordinated behavior. After each experiment session, participants are rewarded for correct guesses with a bonus that is paid in local currency and not in  $E_xCUs$ . Mirroring the system source in muted mode, the message displayed from the social source reads

A survey of traders' expectations show that they on average anticipate the next dividend payout for *< name and ticker >* to be \$ *< number >*

In vivid mode the message displayed reads

**NEWSFLASH: A business survey of traders with experience in trading *< company name and ticker >* reveals that they expect a strong *{improvement; decline}* in the performance of *< company name >*. The *{optimism; pessimism}* of the traders could be attributed to *{improved; worsening}* market *{demand; conditions}* for the company's**

**products. In addition the results from the survey indicate that traders have an increasingly {positive;negative} outlook regarding the financial position of the company. Traders in the survey expect the next dividend for <company name> to {increase; decrease} to \$ < number >**

By specifically using the term *traders* we insinuate that the information is based on feedback from the participants' own inputs. The terms *survey*, *reveal* and *indicate*, as well as absence of references to any authoratative information, are chosen to make the participants aware that the information is linked to their own daemonized survey results and therefore less likely to be as precise as the system source. We also turn to the conditional tense to contrast the indicative sentence structure in the system information. The use of the terms *improvement* and *decline*, *improved* and *worsening* and *increase* and *decrease* hint towards trending between time periods typical of social feedback loops to contrast with the more event driven, direct causal tone from the system source.

### 3.3 Treatments

We have four treatments based on patterns of vividness: sustained, block, escalate and decay. For our control we mute vividness by keeping it permanently turned off<sup>12</sup>. In the sustained treatment regime, participants are exposed at each period to the vivid presentation. The rest of the treatment regimes follow a pattern where the vivid switch is turned on at specific intervals. Specifically block, escalate and decay treatment regimes indicate alternating structures with contrasting, increasing and decreasing vivid treatment intensity. Each cohort of participants is exposed to two of the treatment patterns and each pattern acts as either initial or final treatment in a session. To familiarize participants with the user interface and the trading process, five periods of practice in blind mode precede the initial treatment in each session. We recognize that cohorts, exposed to more intricate patterns as initial treatment, might be less inclined to realize the existence of a pattern compared to cohorts that receive the intricate pattern as final treatment. However, we don't expect this to be significant enough to impact our results.

Appendix C holds a visual representation of the data gathered during the experiment. We didn't exert any control over the direction of the income generated by the instruments, the information from the social feedback loop and the decisions made by the daemons. Table 1 holds an overview of the experimental session

---

<sup>12</sup>We also run a blind treatment with just a basic dashboard with neither system nor social information, rendering the information carrier indistinguishable from the companion instrument. This session is only relevant for this project insofar as some participants were exposed before or after a treatment to a blind session. In order to include the data, we employ the output of these blind sessions as a supplicant control in some regression tests.

Treatment	No. of participants							Obs	
	one	two	three	four	five	six	total	vivid	total
Blind	–	43	–	–	35	–	78	–	1560
Muted	–	–	35	–	–	36	71	<b>0</b>	1420
Sustain	46	–	–	–	–	36	82	<b>1640</b>	1640
Block	46	–	–	45	–	–	91	<b>910</b>	1820
Escalate	–	–	–	45	35	–	80	<b>960</b>	1600
Decay	–	43	35	–	–	–	78	<b>936</b>	1560
Total								<b>4446</b>	9600

Table 1: Experiment Sessions. Information is enhanced with vivid attributes in the sessions according to vividness patterns. Muted Treatment Pattern: all information is non-vivid. Sustain Treatment Pattern: all information is displayed in vivid mode. Block Treatment Pattern: 5 consecutive periods of vivid information displays alternate with 5 periods of non-vivid information displays. Escalate Treatment Pattern: vivid displays come in sequences of a single, 2 and 3 consecutive vivid displays each alternating with a single non-vivid display. Decay Treatment pattern: vivid displays come in sequences of 3 and 2 consecutive and a single vivid display, each alternating with a single non-vivid display. Blind sessions are sessions without any information displayed.

design. Table 2 summarizes the direction of the system source and the survey response input to the social source <sup>13</sup>.

## 4 Hypotheses

Cognitive constraints restrict the ability of individuals to pay attention to all available information in a decision making process. Limited resources of attention activate processes that steer attention to information perceived as most relevant to the individual. Effective stimuli temporarily relax cognitive constraints or shift attention between competing tasks (Arrington, 2008). We posit that vivid portrayals have the ability to influence the individual behavioral processes and thus result in effects that transcend market aggregation.

We construct rudimentary hypotheses along Nisbett and Ross’s core attributes of vividness in the context of emotional engagement, imagery generation and proximity. Consequently, we measure effects of vividness on size and composition of the order book, on trade flows conditional to declared sentiment and then on market reactions to content.

<sup>13</sup>Survey responses, on average, tend to be more positive than negative. Antweiler and Murray (2004) examine message boards on social media and also find a bullish tone on average.

System Messages	All	Vivid			
Total	90				
Down	49	32			
Up	41	22			
Social					
participant survey responses					
	total entries	daemonized	entries	vivid states	daemonized
negative entry	2956	3105	614		645
positive entry	6644	6495	1387		1356

Table 2: Direction of random occurrences and survey outcomes

In our controlled environment, switching both of these information sources between non-vivid and vivid states constitutes the primary stimulus<sup>14</sup> for our treatments.

First, we introduce a general hypothesis reflecting just engagement. If vivid information engages participants more than non-vivid information, then

- H1: Vivid treatment of information leads to thicker order book components<sup>15</sup>.

Next, we examine the moderating effect of vividness on the interaction between information and sentiment. We expect the vivid portrayal of social information to induce more proximity than the system information, since the social information makes the subjects directly confront their latent sentiments. With social information, the proximity induced by vividness reinforces their sentiment in most instances (as a majority exhibits optimism most of the time), while with the system information the participants receive a mixed signal: on average half of the time it reinforces and half of the time it conflicts. Therefore, we would expect the interaction of vivid portrayal of information with sentiment to be different depending on the source of the information, leading to the following hypothesis.

- H2: Vivid portrayals of information interact with the sentiment participants declare, which gets manifested differently depending on the source of the information.

<sup>14</sup>In the literature, saliency and availability are the other auxiliary stimuli that, together with vividness, form the attention triptych. Saliency manifests through contrasting the information with the price paths and through variations in the source of information undergoing vivid treatment. The reference in the social source to the survey input potentially activates the availability heuristic.

<sup>15</sup>There might also be an effect on activation or attention-driven switching between tasks. However, in our experiment there is no alternative task to measure this effect.

Finally, we construct a set of hypotheses that examine the effects of vividness on aggregate market variables by contrasting the information based on the source (system or social).

In each trading period, market clearing based on individual decisions leads to an entry in a price chain that evolves alongside the slipstream generated by the cash flows. Deviations between the prices from the market clearing process and the indicative prices from the slipstream, reveal a potential to revert to fundamental levels through trading.

The elevated information level from the system source yields a more reliable prediction of the forthcoming value in the slipstream. In contrast, the social feedback source provides relatively less reliable information of the forthcoming slipstream value.

By inducing imagery and proximity, vividness influences the extent to which information content is incorporated in order book entries. Through the following hypotheses, we test how this effect transcends to the aggregate level for each of the two sources.

- H3 : Vivid treatment of system information adjusts priors more strongly.
- H4: Vivid treatment of social content confirms priors.

Next, we discuss the hypothesis tests and then relate the findings to stylized facts with respect to turnover and price patterns.

## 5 Results

### 5.1 Elevated Attention and Intensity

Order book components indicate willingness to trade. We measure the response of individuals by the size of the order book and its components, expressed as a ratio to the number of participants in the session:  $\bar{Q}_{bid,t,s} = \frac{\sum_{n=1}^N q_{bid,n,t,s}}{N_s}$   $\bar{Q}_{ask,t,s} = \frac{\sum_{n=1}^N q_{ask,n,t,s}}{N_s}$   $\bar{Q}_{book,t,s} = \frac{\bar{Q}_{bid,t,s} + \bar{Q}_{ask,t,s}}{2}$  at time  $t$  during session  $s$  with  $q_{bid,n,t,s}$  and  $q_{ask,n,t,s}$ , the bid and ask quantities respectively, entered by participant  $n$  at time  $t$ . Reactions conditional on treatments then indicate elevated attention states.

We present the findings through box and violin plots, and in a regression analysis. Box plots provide a visual summary of the first and third quartile, median and tail characteristics. Violin plots display the kernel probability density function. We find that vivid presentations lead to significantly larger order book sizes (see Figure 1). Both bid and ask sides of the order book increase (see Figures 2 and 3). When the vivid switch is turned on, the number of quotes entered is significantly higher and the willingness to trade especially pronounced at the bid side of the book. We use dummies for the treatments ( $D_{VON}^{Sys}$ ,  $D_{VON}^{Soc}$ ,  $D_{VOFF}^{Sys}$ ,  $D_{VOFF}^{Soc}$  with *Sys* and *Soc* indicating the source (system or social respectively)

Variable	$\bar{Q}_{book,t,s}$	$\bar{Q}_{bid,t,s}$	$\bar{Q}_{ask,t,s}$
Vivid Switches			
$\beta_{VON}^{Sys} - \beta_{VOFF}^{Sys}$	19.33***	17.58***	1.758*
standard error	6.437	6.211	1.119
$\beta_{VON}^{Soc} - \beta_{VOFF}^{Soc}$	20.07***	18.43***	1.64
standard error	6.607	6.376	1.149
Control Variables			
$R_{t-1}$	-53.85***	-40.47**	-13.38***
standard error	19.48	18.79	3.387
$CF_{t-1}$	2.655	8.818	-6.163***
standard error	10.43	10.07	1.814
$R^2$	0.111	0.092	0.226

Table 3: The effect of vividness on order book size. The regressions represent 95% of the data. First differences bring the total number of observations from 240 to 228. We winsorize (at 5% level divided equally between both sides of the tail) all dependent variables and returns, reducing the data to 216 observations. 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.

and  $V^{ON}$  and  $V^{OFF}$  indicating the vivid or non-vivid mode. We also control for the effect of the previous period return  $R_{t-1}$  and for the most recent percentage changes in cash flow  $D_{t-1}$ .

$$\begin{aligned}
\bar{Q}_{orderbook,t,s} = & \beta_{VON}^{Sys} D_{VON}^{Sys} + \beta_{VON}^{Soc} D_{VON}^{Soc} \\
& + \beta_{VOFF}^{Sys} D_{VOFF}^{Sys} + \beta_{VOFF}^{Soc} D_{VOFF}^{Soc} \\
& + \beta_{blind} D_{blind} + \gamma_R R_{t-1} + \gamma_{CF} \Delta CF_{t-1} \epsilon
\end{aligned} \tag{1}$$

with *orderbook* indicating the measure for the orderbook *bid*, *ask* and *book*.

Table 3 reports the difference in coefficients between the vivid and non-vivid states. Order book sizes are significantly larger in vivid states.

In addition to thicker order books, the differences between average bid and average ask ( $\frac{\bar{P}_{bid,t,s} - \bar{P}_{ask,t,s}}{E(P)_T}$ ) are significantly larger when the information is presented vividly, leading to more overlap between the bid side and the ask sides of the order book and therefore larger propensity to trade when information is presented vividly (see Figure 4)

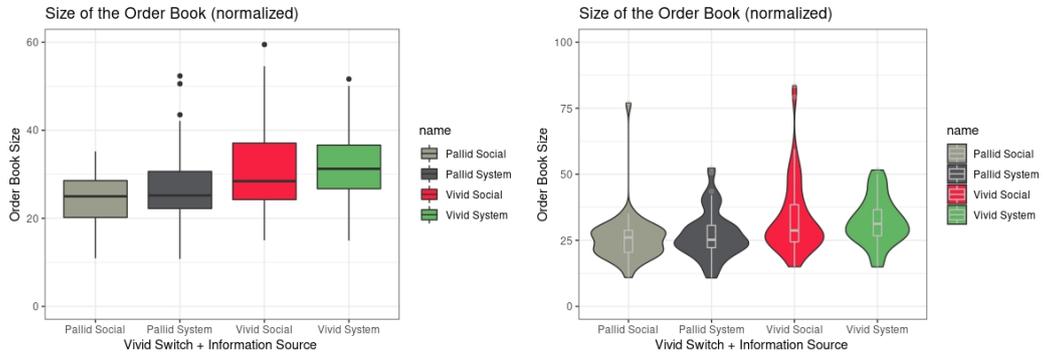


Figure 1: Book size

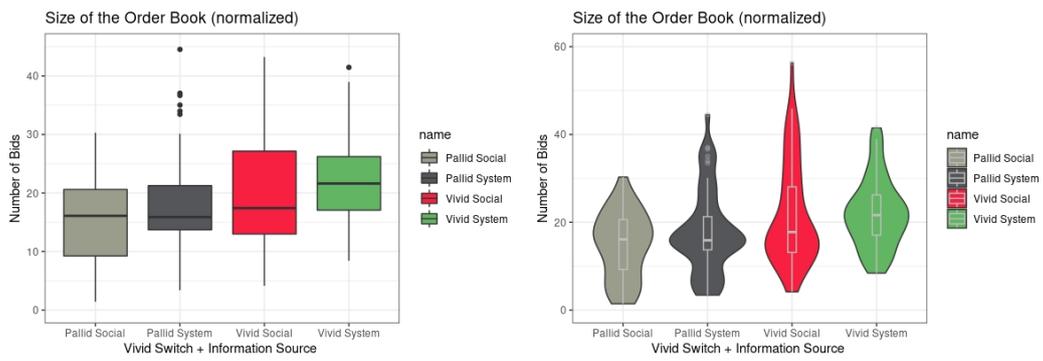


Figure 2: Bid size

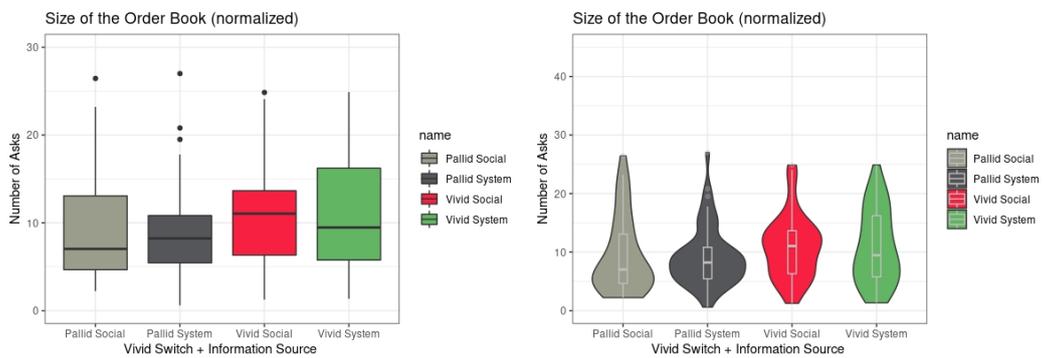


Figure 3: Ask size

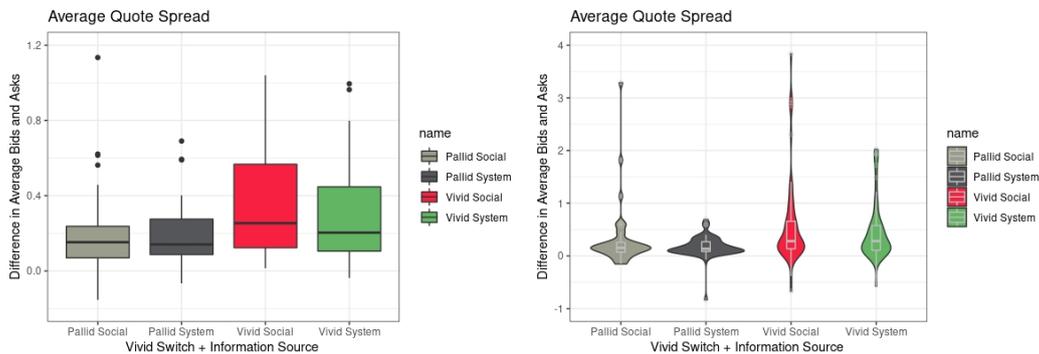


Figure 4: Spread

We run a regression to confirm the display in the box and violin plots:

$$\frac{\bar{P}_{bid,t,s} - \bar{P}_{ask,t,s}}{E(P)_T} = \beta_{VON}^{Sys} D_{VON}^{Sys} + \beta_{VON}^{Soc} D_{VON}^{Soc} + \beta_{VOFF}^{Sys} D_{VOFF}^{Sys} + \beta_{VOFF}^{Soc} D_{VOFF}^{Soc} \quad (2)$$

$$+ \beta_{blind} D_{blind} + \gamma_R R_{t-1} + \gamma_{CF} \Delta CF_{t-1} + \epsilon.$$

The regression results in Table 4 indicate more overlap between the bid side and the ask side of the book when the information is presented in vivid mode: the difference between average bids and average asks widens, indicating more potential for trade when the market clears.

## 5.2 Sentiment and Trade Flows

In our next hypothesis test, we determine whether the interference from information treatments and turning on the vivid mode is different between the group of participants who indicate a positive and a negative outlook for the forthcoming cash flow. This enables us to examine if vividness of information, irrespective of the source, heightens identification with the prior survey choice.

The survey results allow us to divide participants into proclaimed optimists and pessimists. Figure 5 summarizes participants solicited responses over time. The Wald-Wolfowitz run tests in Table 5 are indicative that the changes in responses are not random. For all treatment regimes the sentiment measure has shorter runs than would be expected from a random pattern. This indicates that the process exhibits strong mean reversion. The mean sentiment measure across all session is 69%.

The market clearing mechanism allows for trades when the bid and ask order book entries overlap. By maximizing the volume as the determinant for finding the clearing price, the difference between the median of asks and the median of bids is a prime candidate for finding the inclination to trade. Examining the bimodality of the entries along the two sentiment groups sheds light on the flow between the

	$\frac{\bar{P}_{bid} - \bar{P}_{ask}}{E(P)_T}$	$\frac{\bar{P}_{bid} - \bar{P}_{ask}}{E(P)_T}$
	information carrier	companion
Vivid Switches		
$\beta_{VON, Sys} - \beta_{VOFF, Sys}$	0.332***	0.184***
standard error	0.114	0.077
$\beta_{VON, Soc} - \beta_{VOFF, Soc}$	0.393***	-0.134*
standard error	0.117	0.08
Control Variables		
$R_{t-1}$	-0.856**	0.18
standard error	0.346	0.141
$CF_{t-1}$	-0.644***	-0.643**
standard error	0.185	0.253
$R^2$	0.169	0.085

Table 4: The effect of the vivid switch on bid and ask differentials. The regressions represent 95% of the data. First differences bring the total number of observations from 240 to 228. We winsorize (at 5% level divided equally between both sides of the tail) all dependent variables and returns, reducing the data to 216 observations. 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.

Session Number	sentiment measure			actual runs	Wald-Wolfowitz	
	decrease	increase	unchanged		expected runs	st.dev
1	17	17	5	22	18.0	2.87
2	21	16	2	20	19.2	2.86
3	17	19	3	28	18.9	2.95
4	16	19	4	19	18.4	2.89
5	19	17	3	26	18.9	2.95
6	17	16	6	21	17.5	2.82
total	107	104	23	136	106.5	7.24

Table 5: Changes in Sentiment Measures and Wald-Wolfowitz Runs Tests. Actual and expected runs are based on counting the number of periods where the sentiment measure deviates from that of the preceding period.

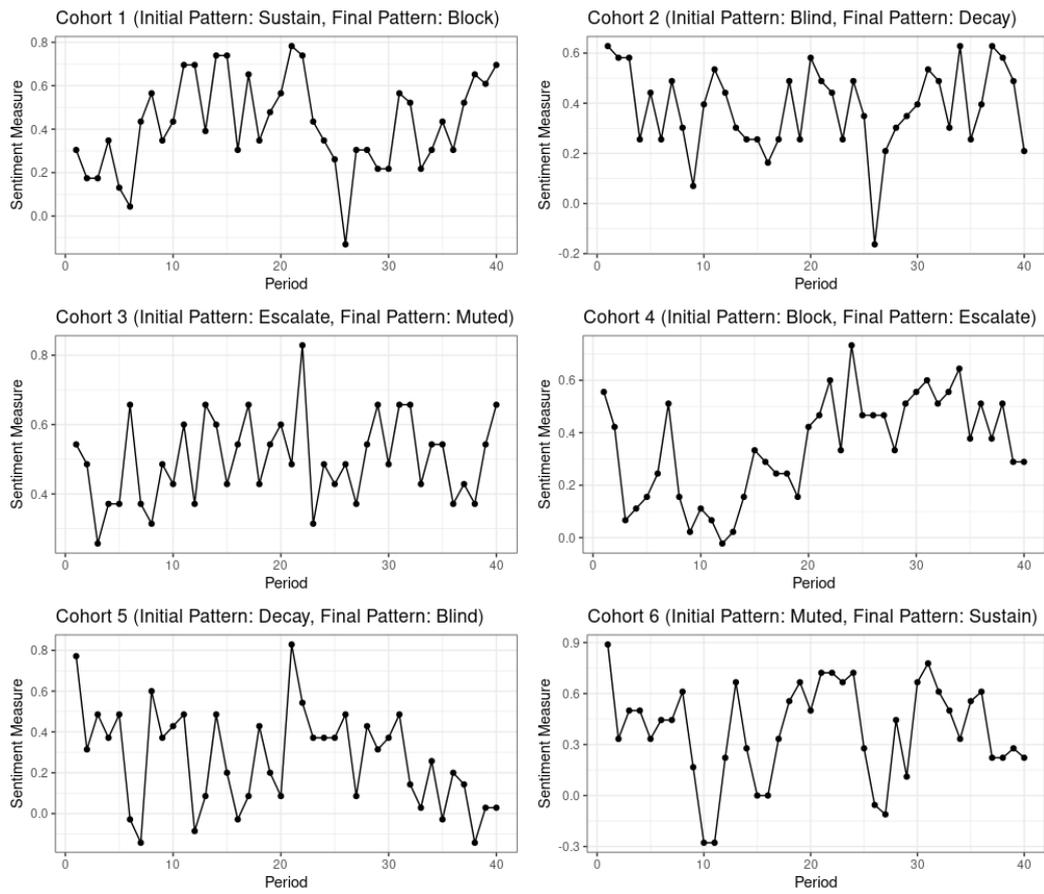


Figure 5: Sentiment concentration measured as  $\frac{N_{optimists} - N_{pessimists}}{N_{optimists} + N_{pessimists}}$  for 6 cohorts (2 sessions of 20 periods).

groups and the mechanism behind the flow. We run regressions for each of the following four combinations.

$$\begin{aligned}
\tilde{X}_{t,v}^{ask\ opt} - \tilde{X}_{t,v}^{bid\ opt} &= \alpha_{bid\ opt;v}^{ask\ opt} + \rho_{bid\ opt;v}^{ask\ opt} SC_t + \epsilon_{1,v} \\
\tilde{X}_{t,v}^{ask\ opt} - \tilde{X}_{t,v}^{bid\ pes} &= \alpha_{bid\ pes;v}^{ask\ opt} + \rho_{bid\ pes;v}^{ask\ opt} SC_t + \epsilon_{2,v} \\
\tilde{X}_{t,v}^{ask\ pes} - \tilde{X}_{t,v}^{bid\ opt} &= \alpha_{bid\ opt;v}^{ask\ pes} + \rho_{bid\ opt;v}^{ask\ pes} SC_t + \epsilon_{3,v} \\
\tilde{X}_{t,v}^{ask\ pes} - \tilde{X}_{t,v}^{bid\ pes} &= \alpha_{bid\ pes;v}^{ask\ pes} + \rho_{bid\ pes;v}^{ask\ pes} SC_t + \epsilon_{4,v}
\end{aligned} \tag{3}$$

with  $v = \{\text{System Vivid; Social Vivid; System Non-Vivid ; Social Non-Vivid; Blind}\}$  indicating the source and vivid mode,  $\tilde{X}_{\{bid;ask\},\{opt;pes\},v}$  representing the median bid and ask entered by either of the sentiment groups and  $SC_t = \frac{N_{optimists} - N_{pessimists}}{N_{optimists} + N_{pessimists}}$  the sentiment concentration measure at time  $t$ .

The results in Table 6 show that in treatments with vivid portrayal of social news, participants' reactions conditional on the level of the overall sentiment measure follow a different pattern from both (a) when the social information is non-vivid and (b) when the information originates from the system source irrespective of the vivid mode.

The difference in reaction is strong and consistent within and between groups. When social information is displayed vividly, differences between median asks and median bids are lowest when sentiment is less concentrated around optimists. Lower differences between median asks and median bids increase the propensity to trade. The reverse is true for the other types of news: differences between median asks and bids decrease when sentiment is concentrated around optimists. In the vivid mode, intercepts are smaller for social news than for system news and coefficients for system information and for social information are of opposite sign.

As the market mechanism chooses a single price by maximizing volume, the market clearing price tends to pronounce flows between the two sentiment groups when the sentiment measure tends to zero in vivid social states (a sentiment measure around zero indicates an equal amount of optimists and pessimists). When the sentiment measure indicates more concentration in opinion, differences between the median bid and median ask tend to be narrower in system states. The market mechanism, by maximizing the volume of trade, then tends to favor transaction within the largest group (in our case these are mostly the proclaimed optimists). So each time the sentiment measure strengthens, trades tend to spike between optimists, and when the sentiment measure indicates more divided opinions, instruments flow between participants with different sentiments.

The effect is confirmed by the flow resulting from executed trades given in Table 7. Vivid displays of social information leads to a significant flow from pessimists to optimists. During the other regimes, we do not detect such a flow. We run the

Ask Optimists - Bid Optimists					
	System		Social		Blind
	Non-Vivid	Vivid	Non-Vivid	Vivid	None
$\rho_{bid\ opt ; v}^{ask\ opt}$	-33.37	-96.57**	-65.74	0.323	132.4***
standard error	18.14	31.80	61.66	41.52	35.43
$\alpha_{bid\ opt ; v}^{ask\ opt}$	44.99***	84.85***	77.60*	55.47**	-10.43
standard error	8.15	13.92	29.40	18.99	13.48
$R^2$	0.06	0.03	0.16	< 1%	0.27
Ask Optimists - Bid Pessimists					
	System		Social		Blind
	Non-Vivid	Vivid	Non-Vivid	Vivid	None
$\rho_{bid\ pes ; v}^{ask\ opt}$	-85.42	-25.96	-192.8	119.4*	115.5*
standard error	71.13	45.28	98.92	51.55	43.27
$\alpha_{bid\ pes ; v}^{ask\ opt}$	55.23	67.92**	141.2	23.43	12.84
standard error	31.96	19.54	46.61	23.19	16.34
$R^2$	0.03	< 1%	0.10	0.09	0.17
Ask Pessimists - Bid Optimists					
	System		Social		Blind
	Non-Vivid	Vivid	Non-Vivid	Vivid	None
$\rho_{bid\ opt ; v}^{ask\ pes}$	-46.76*	-112.7**	-108.9	25.28	131.7**
standard error	18.11	37.56	78.65	42.85	41.39
$\alpha_{bid\ opt ; v}^{ask\ pes}$	48.00 ***	84.20 ***	81.92 *	39.91	-18.48
standard error	7.86	16.13	35.30	19.49	15.48
$R^2$	0.11	0.09	0.05	< 1%	0.21
Ask Pessimists - Bid Pessimists					
	System		Social		Blind
	Non-Vivid	Vivid	Non-Vivid	Vivid	None
$\rho_{bid\ pes ; v}^{ask\ pes}$	-30.63	-36.29	-130.98	165.2**	109.2*
standard error	25.30	50.37	118.3	50.10	40.66
$\alpha_{bid\ pes ; v}^{ask\ pes}$	47.64***	65.90**	121.86*	4.91	5.99
standard error	10.99	21.29	52.23	22.400	15.065
$R^2$	0.03	0.01	0.04	0.17	0.17

Table 6: The effect of the interaction of the vivid mode with sentiment on median ask-bid differentials. \*\*\* denotes significance at the 0.1% level, \*\* denotes significance at the 1% level but not at the 0.1% level and \* denotes significance at the 5% level but not at the 0.1% level

	<i>Trade flow</i> info carrier
Vivid Social	14.59322
p-value	0.0645
Vivid System	-6.081633
p-value	0.2635
Non-vivid Social	-1.897436
p-value	0.4404
Non-vivid System	2.7165981
p-value	0.41

Table 7: Trade flow from pessimists to optimist. Differences in mean flow from pessimist sellers to optimist buyers and mean flow from optimist sellers to pessimist buyers. p-values from Wilcoxon Rank Test.

following regression to measure the effect on turnover.

$$\begin{aligned}
Turnover_t = & \iota_{VON}^{Sys} D_{VON}^{Sys} + \iota_{VON}^{Soc} D_{VON}^{Soc} \\
& + \iota_{VOFF}^{Sys} D_{VOFF}^{Sys} + \iota_{VOFF}^{Soc} D_{VOFF}^{Soc} \\
& + \iota_{blind} D_{blind} + \tau turnover_{t-1} + \epsilon_{turnover}
\end{aligned} \tag{4}$$

We find that vivid social displays are characterized by significantly higher turnover compared to other information regimes (see Table 8). Potentially this is caused by lower within and between differences in group median ask and bid when sentiment is evenly distributed and social information is displayed vividly. In contrast, for the other information formats lowering of spreads occurs when the sentiment measure indicates concentrated sentiment.

### 5.3 Focus and Distraction: Vivid treatments adjust and confirm priors

Effects of activating the vivid switch are content-sensitive. Constructional system information containing higher levels of informativeness guides individuals to focus on narrowed distributional properties and adjusts priors. Vivid portrayal of social information distracts individuals from directional-relevant information sources and confirms priors.

On average, two thirds of the participants indicate a positive outlook for the future cash flow in the survey outcome. Therefore this leads the social feedback mechanism to display expectations of higher cash flows on the information carrier in nine out of ten periods.

The market, as we would expect, plays several roles. As a coordination platform it enables participants who act on information through preferences to ex-

Variable	$Turnover_t$ info carrier	$Turnover_t$ companion
$\tau(turnover_{t-1})$	0.632***	0.020
standard error	0.053	0.069
Vivid Switches		
$\iota_{VON}^{Sys} - \iota_{VOFF}^{Sys}$	-0.085	-0.878
standard error	6.951	3.77
$\iota_{VON}^{Soc} - \iota_{VOFF}^{Soc}$	14.05**	10.03***
standard error	7.284	3.94
$R^2$	0.409	0.043

Table 8: Turnover. The regressions represent 95% of the data. First differences bring the total number of observations from 240 to 228. We winsorize (at 5% level divided equally between both sides of the tail) all dependent variables and returns, reducing the data to 216 observations. 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.

change the instruments. Through the trading process the market also aggregates decisions from participants to traded prices and volumes. Consecutive trading sessions create a stream of market-generated information. Participants act on a combination of three information flows: the directional system information flow, the social feedback information loop and information from the market aggregation process.

We introduce dummy variables to measure the effect of the vivid switch on the variables from the market-aggregating process and we control the regressions for the previous period percentage price change, the price - slipstream ratio and the change in realized cash flows.

To filter out the effect that vividness exhibits in incorporating the directional information, we employ separate dummy pairs to indicate the vivid mode for each direction. The effect of vividness on the information from the social source, which as we know presents almost no foresight on the direction of the flow, is captured by a single dummy pair.

$$\begin{aligned}
R_t = & \beta_{VON}^{Sys^\oplus} D_{VON}^{Sys^\oplus} + \beta_{VON}^{Sys^\ominus} D_{VON}^{Sys^\ominus} + \beta_{VOFF}^{Sys^\oplus} D_{VOFF}^{Sys^\oplus} + \beta_{VOFF}^{Sys^\ominus} D_{VOFF}^{Sys^\ominus} \\
& + \beta_{VON}^{Soc} D_{VON}^{Soc} + \beta_{VOFF}^{Soc} D_{VOFF}^{Soc} + \beta_{blind} D_{blind} \\
& + \gamma_R R_{t-1} + \gamma_C F \Delta C F_{t-1} + \epsilon_1
\end{aligned} \tag{5}$$

$$\begin{aligned}
\frac{P_t}{E(P_{\bar{T}})} &= \beta_{VON}^{Sys^\oplus} D_{VON}^{Sys^\oplus} + \beta_{VON}^{Sys^\ominus} D_{VON}^{Sys^\ominus} + \beta_{VOFF}^{Sys^\oplus} D_{VOFF}^{Sys^\oplus} + \beta_{VOFF}^{Sys^\ominus} D_{VOFF}^{Sys^\ominus} \quad (6) \\
&+ \beta_{VON}^{Soc} D_{VON}^{Soc} + \beta_{VOFF}^{Soc} D_{VOFF}^{Soc} + \beta_{blind} D_{blind} \\
&+ \gamma_{P/S} \frac{P_{t-1}}{E(P_{\bar{T}})} + \gamma_{CF} \Delta CF_{t-1} + \epsilon_2
\end{aligned}$$

We report the difference between the vivid and non-vivid directional system dummies, and the vivid and non-vivid social dummies in Table 9. Coefficients indicate system news is significantly directional and the price-slipstream ratio narrows when system news is displayed. The impact on both is stronger when the news is displayed vividly. This is in line with our hypothesis (H3) although the differences between the vivid and non-vivid mode cannot be shown to be significantly different.

We do find clear evidence that confirms our distraction hypothesis (H4). Vivid treatments of information sourced from social feedback lead to significantly higher returns and compared to non-vivid states do not lead to a return to more rational outcomes as measured by the price-slipstream ratio. Thus, even the faint information signal that the news from the social source conveys, significantly interferes with the participants' decisions, when it is displayed vividly.

## 6 Further Discussion

The effects we described earlier are derived from measuring the instantaneous<sup>16</sup> reaction of turning on the vivid switch. In our design, the order in which we deliver the vivid treatments during the sessions is designed to create specific patterns. The different patterns weave smaller vivid sequences into larger ones with varying levels of intensity and intricacy. The patterns enter the experiment twice: for one cohort of participants as the first treatment and for another cohort as the second treatment.

Mirroring the contemporaneous results of vividness we discussed earlier, sustained vivid treatment sequences display significantly larger order book sizes and greater overlap of bid and ask sides of the order book compared to muted sequences (see Figures 6 and 7). The mixed treatment patterns display effects (bimodality in block treatment, and boost and bust patterns for escalate and decay treatments) on order book size and extent of overlap between bid and ask sides that correspond to our intended design. Order book sizes and the degree of overlap between bid and ask sides for mixed treatment designs lie in-between those for the sustained and muted treatments.

---

<sup>16</sup>The effects induced by exposure to vividness might not necessarily be just instantaneous. Instead of directly measuring the effect of delayed reaction, we discuss the long-lasting effects by examining the vivid patterns.

Variable	$R_t$	$R_t$	$\frac{P_t}{E(P_T)}$	$\frac{P_t}{E(P_T)}$
	info carrier	companion	info carrier	companion
<hr/> System <hr/>				
$\beta_{VON}^{Sys^{\oplus}} - \beta_{VON}^{Sys^{\ominus}}$	0.063**	0.037	-0.327**	0.027
standard error	0.028	0.055	0.151	0.077
$\beta_{VOFF}^{Sys^{\oplus}} - \beta_{VOFF}^{Sys^{\ominus}}$	0.045*	-0.005	-0.289**	-0.023
standard error	0.027	0.052	0.143	0.1073
<hr/> Social <hr/>				
$\beta_{VON}^{Soc} - \beta_{VOFF}^{Soc}$	0.034*	0.042	0.095	0.053
standard error	0.020	0.039	0.106	0.055
<hr/> Control Variables <hr/>				
$R_{t-1}$	0.255***	0.328	-0.121	0.154
standard error	0.059	0.319	0.069	0.1
$CF_{t-1}$	0.245***	0.185	0.270	0.095
standard error	0.031	0.179	0.125	0.189
$\frac{P_{t-1}}{E(P_T)}$	—		0.902***	0.797***
standard error	—		0.036	0.047
$R^2$	0.372	0.051	0.806	0.646

Table 9: Effects of Vividness on Return and Pricing. The regressions represent 95% of the data. First differences bring the total number of observations from 240 to 228. We winsorize (at 5% level divided equally between both sides of the tail) all dependent variables and returns, reducing the data to 216 observations. 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.

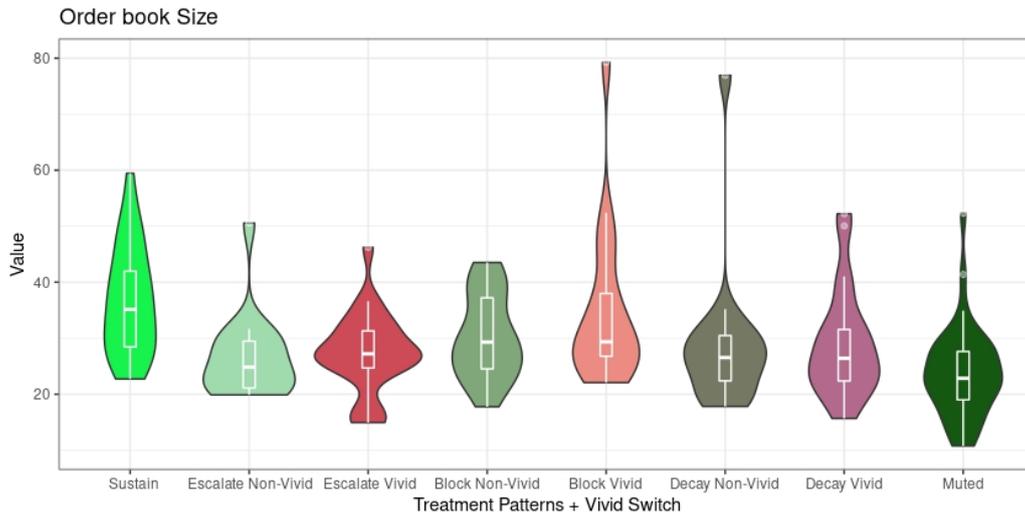


Figure 6: Treatment Patterns and Orderbook Size

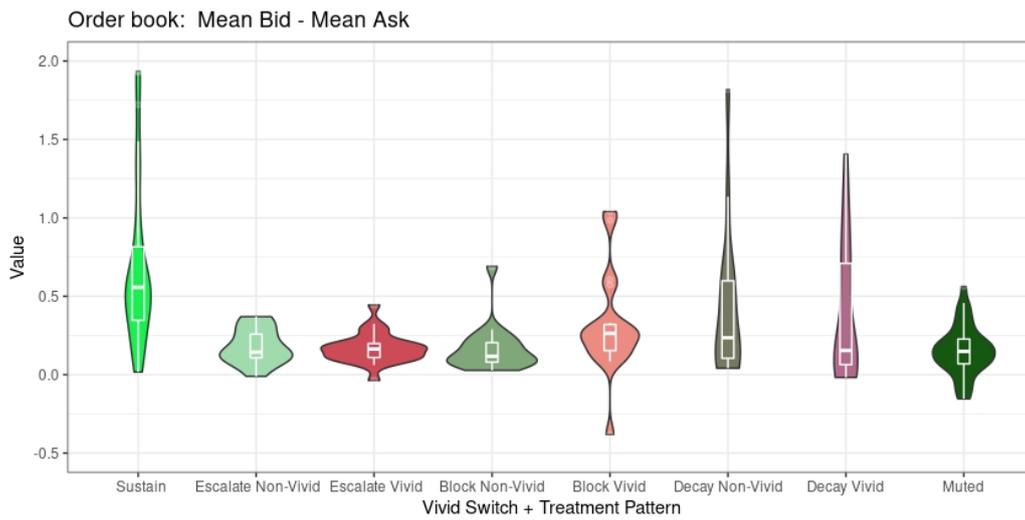


Figure 7: Treatment Patterns and Average Ask-Bid Differences

In essence, we are agnostic about which of the effects we discussed earlier (focus or distraction) dominates over time. However we expect to find stylized facts to form over time related to the degree of vividness in the treatment patterns. To assess the vivid treatment pattern effect, we examine the effects over the sustained time period from the entry to the exit of a 20-period experiment.

Larger pattern formations lead to stylized observations not unimportant from a spin doctoring perspective. We posit that the intensity and sophistication of the treatments exerts influence on the perceived worth of participating in the experiment and that this reflects the sentiment (generally positive) of the participants.

As can be seen from Figures 8, we find in general that the difference between traded prices and the fundamental slipstream widens if treatment regimes are more vivid. The treatment regimes with all information displayed vividly, sustain prices above the slipstream for all periods. This is not the case for the treatment regimes with the vivid mode turned off or switched on for only half of the information presentations. For treatment regimes with more than half of the information presented in vivid mode, one out of two sessions sustain prices above the slipstream.

## 7 Conclusion

We find strong evidence that vividness is a tool to capture attention and engage participants in market environments. Participants exposed to vivid information indicate more willingness to trade and the resulting bid and ask entries in order books overlap more when information is displayed vividly. System-generated information with high information content leads to more focus and adjust prices towards fundamental values while information from a social source confirms generally bullish priors. Vivid social information significantly confirms priors more strongly than non-vivid social information. We also find evidence that vividness interacts with sentiment to create a trade flow from self-declared pessimists to optimists. The combination of the effects of vividness allow for vividness patterns to influence market variable dynamics over time.

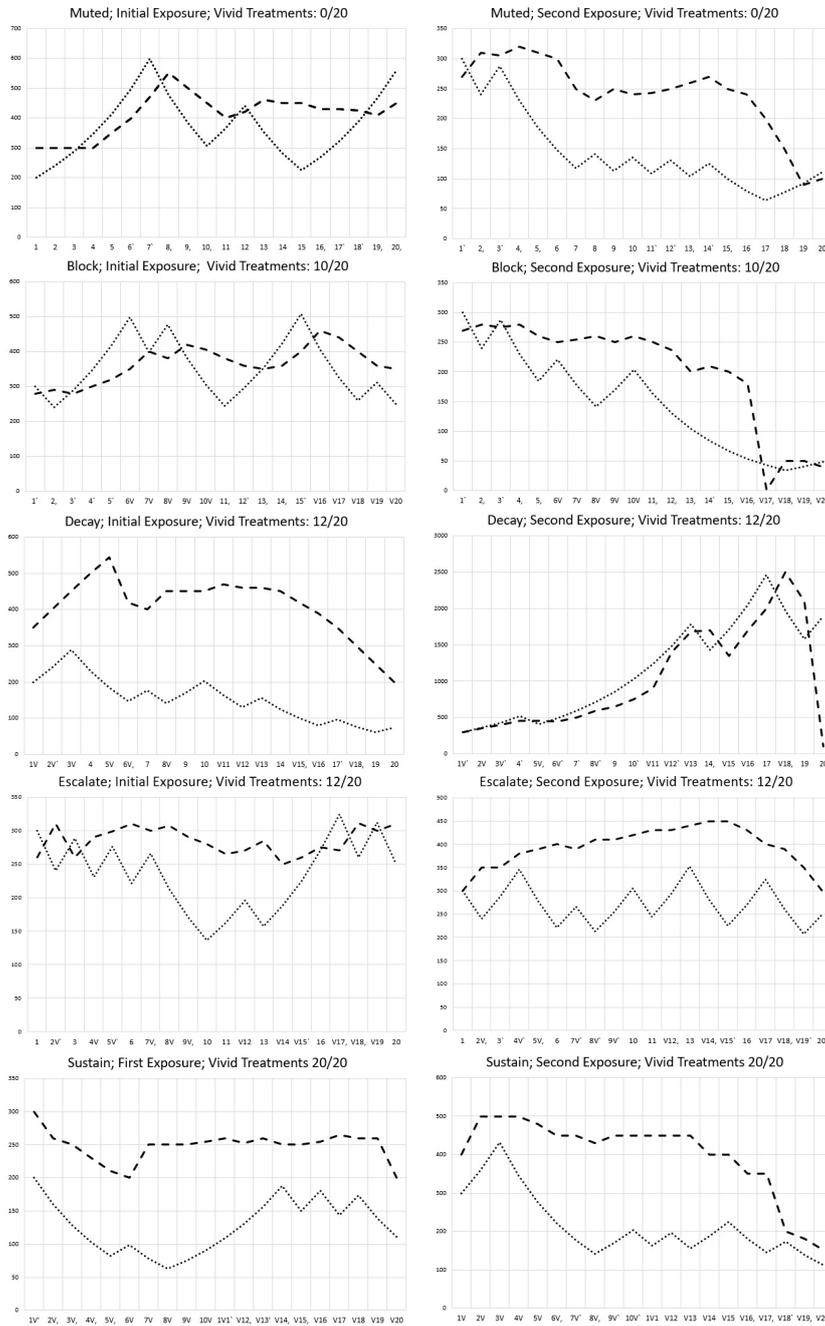


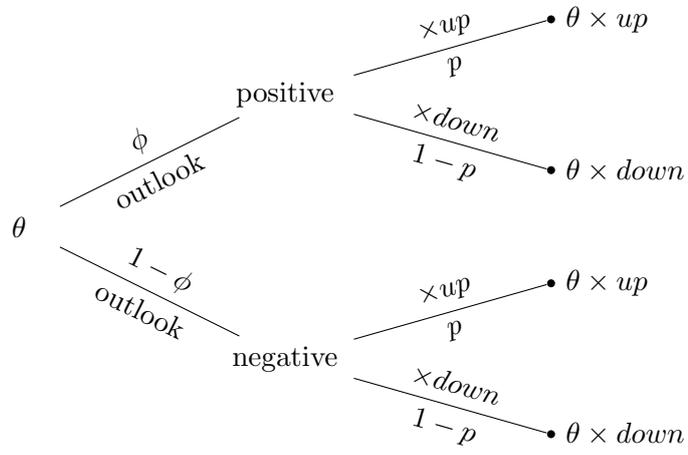
Figure 8: Comparison of Traded Price (Full line) versus Slipstream (Dotted Line); Top to Bottom: Treatment patterns ordered by vivid intensity (# of vivid / total number): muted mode (0/20), block mode (10/20), decay mode (12/20), escalate mode (12/20) and sustain mode (20/20). The combination of a V with a numeral point to periods where the vivid switch is turned on. A comma or an apostrophe indicate if system information predicts an increase ”,” or a decrease ”‘” in the next period cash flow. Numerals without punctuation indicate information originates from the social source.

## References

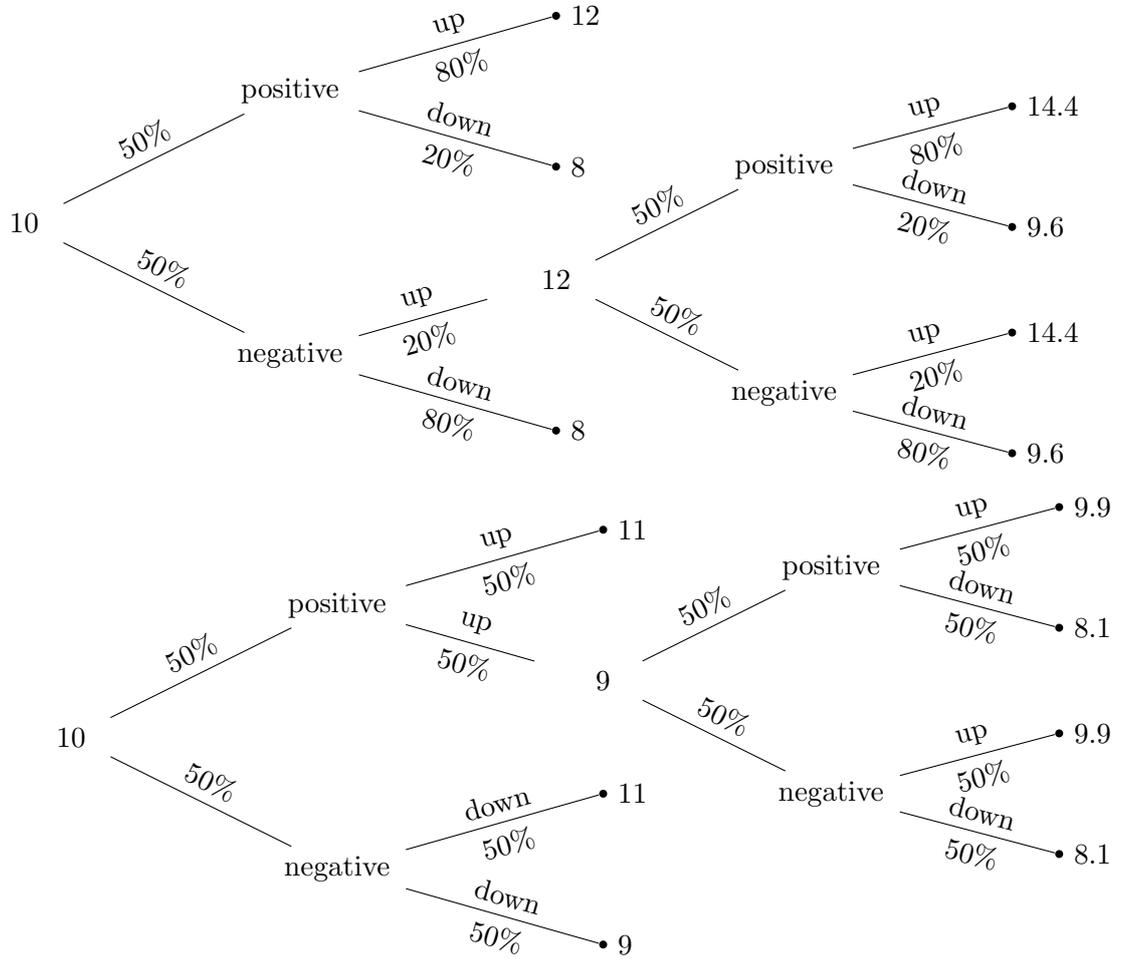
- Antweiler W. and F. Murray (2004). Is all that talk just noise? The information content of Internet stock message boards. *The Journal of Finance* 59, 1259–1294.
- Arrington C. M. (2008). The effect of stimulus availability on task choice in voluntary task switching. *Memory and Cognition* 36, 991–997.
- Bar-Hillel M. (1980). The base-rate fallacy in probability judgments. *Acta Psychologica* 44, 211–233.
- Bar-Hillel M. and B. Fischhoff (1981). When do base rates affect predictions? *Journal of Personality and Social Psychology* 4, 671–680.
- Borgida E. and R. Nisbett (1977). The differential impact of abstract vs. concrete information on decisions. *Journal of Applied Social Psychology* 7, 258–271.
- Brown G.W. and M.T. Cliff (2005). Investor Sentiment and Asset Valuation. *Journal of Business* 78, 405–440.
- Clark N. and D. Rutter (1985). Social categorization, visual cues, and social judgements. *European Journal of Social Psychology* 15, 105–119.
- Collins R., S. Taylor, J. Wood and S. Thompson (1988). The vividness effect: Elusive or illusory? *Journal of Experimental Social Psychology* 24, 1–18.
- Da, Z, J. Engelberg and P. Gao (2015). The sum of all FEARS investor sentiment and asset prices. *Review of Financial Studies* 28, 1–32.
- Damasio A. (1994). *Descartes' Error*. New York, NY: Putnam
- Hirshleifer D., S. Lim and S. Teoh (2009). Driven to distraction: Extraneous events and underreaction to earnings news. *The Journal of Finance* 64, 2289–2325.
- Israeli D., R. Kasznik, and S. Sridharan (2021). Unexpected Distractions and Investor Attention to Corporate Announcements. *Review of Accounting Studies*, forthcoming.
- Kardes, F., M. Cronley and T. Cline (2011). *Consumer Behavior*. Mason, OH: South-Western, Cengage Learning.
- Kennamer J. (1988). News values and the vividness of information. *Written Communication* 5, 108–123.
- Melloni, L., S. van Leeuwen, A. Alink and N.G. Müller (2012). Interaction between bottom-up saliency and top-down control: How saliency maps are created in the human brain. *Cerebral Cortex* 22, 2943–2952.
- Michaely R., A. Rubin and A. Vedrashko (2016). Are friday announcements special? *Journal of Financial Economics* 122, 65–85.
- Nelson M., R. Bloomfield, J. Hales and R. Libby (2001). The effect of information strength and weight on behavior in financial markets. *Organizational Behavior and Human Decision Processes* 86, 168–196.
- Nisbett R. and L. Ross (1980). *Human inference: Strategies and shortcomings of social judgment*. Englewood Cliffs, NJ: Prentice-Hall.
- Reyes R., W. Thompson and G. Bower (1980). Judgmental biases resulting from differing availabilities of arguments. *Journal of Personality and Social Psychology* 39, 2–12.

- Solomon D.H. (2012). Selective publicity and stock prices. *The Journal of Finance* 67, 599–638.
- Tetlock P., M. Saar-Tsechansky and S. Macskassy (2008). More than words: Quantifying language to measure firms' fundamentals. *The Journal of Finance* 63, 1437–1467.
- Tversky A. and D. Kahneman (1983). Extensional versus intuitive reasoning: The conjunction fallacy in probability judgment. *Psychological Review* 90, 293–315.

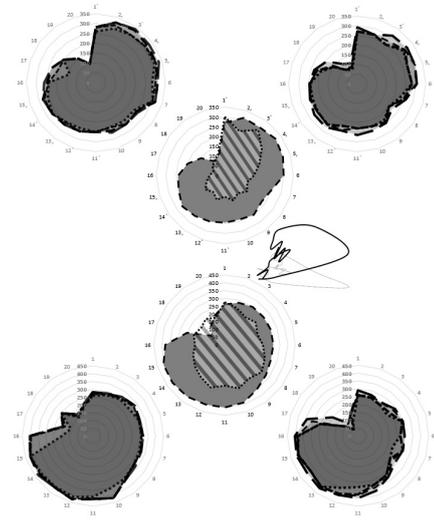
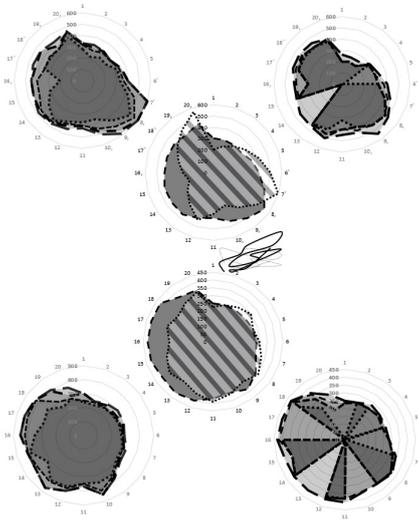
# Appendix A



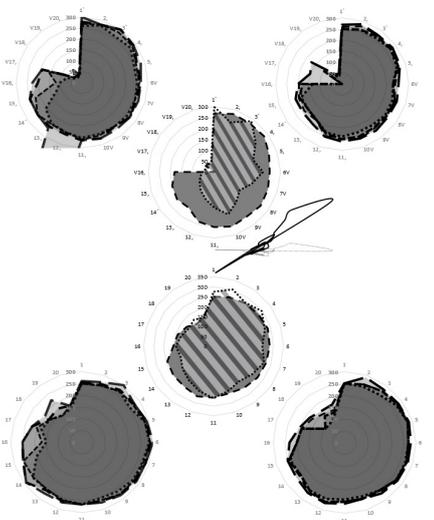
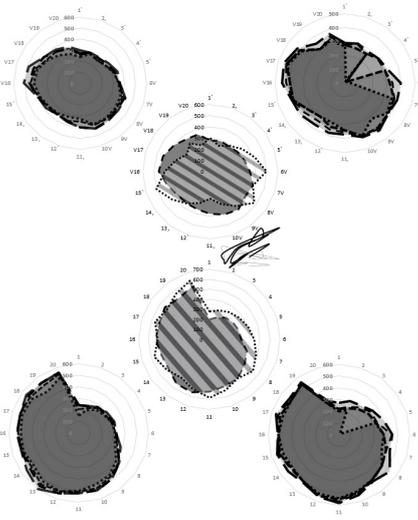
# Appendix B



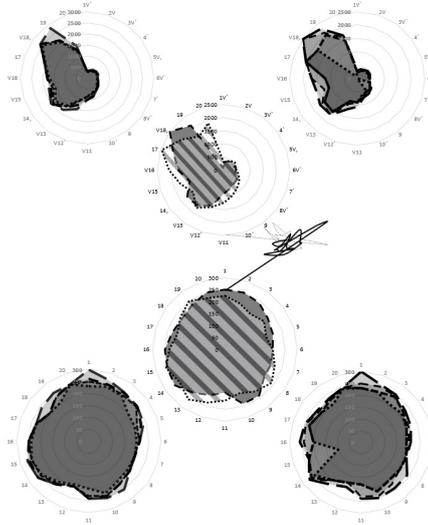
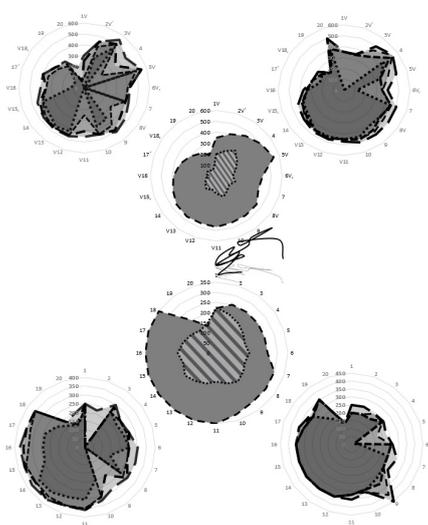
# Appendix C



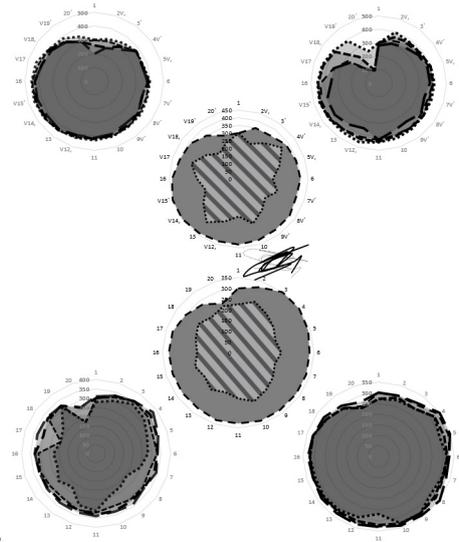
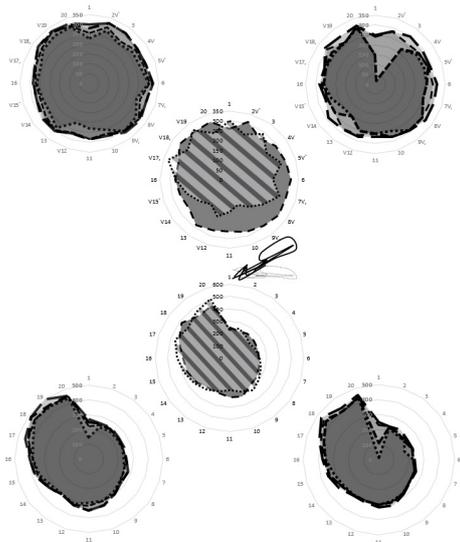
Muted mode



Block mode



Decay Mode



Escalate Mode

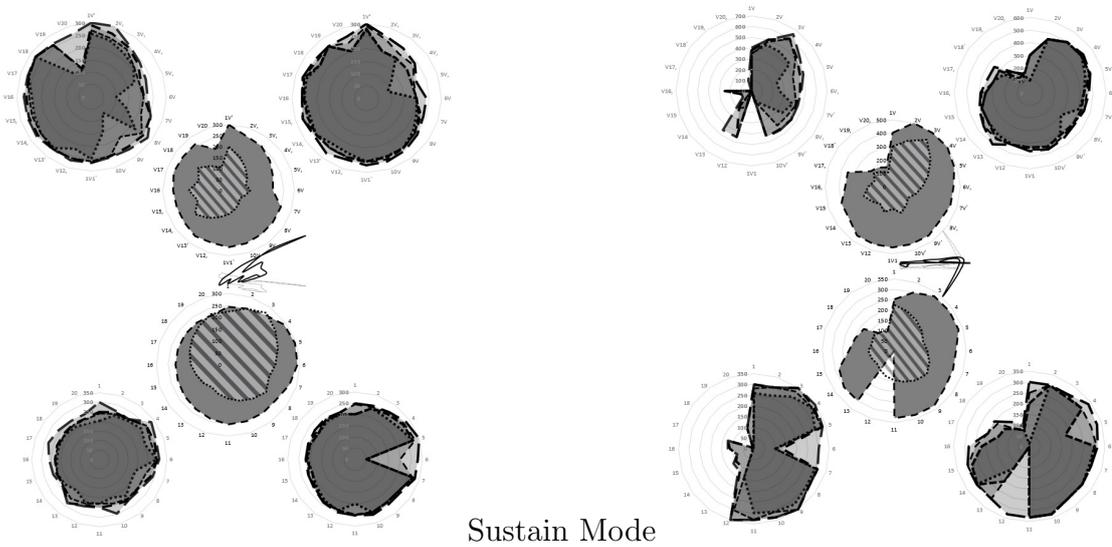


Figure 9: Graphical Data Presentation: 5th, 10th, 20th and 40th percentile Bid and Ask Quotes, Market Price and Slipstream Indicative Prices for each treatment pattern design. Left side: first exposure; right side: second exposure; Within each 20-period treatment session: top left: Best Bid Orders for the information carrier, top right: Best Ask Orders for the information carrier, Bottom Left: Best Bid Orders for the companion instrument, Bottom Right: Best Ask Orders for the companion instrument; middle: slipstream indicative price (dotted line along striped area) and market price (full line along shaded area) for information carrier (top middle) and companion instrument (bottom middle)