

NEURAL BASIS OF ECONOMIC BUBBLE BEHAVIOR

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Abstract—Throughout human history, economic bubbles have formed and burst. As a bubble grows, microeconomic behavior ceases to be constrained by realistic predictions. This contradicts the basic assumption of economics that agents have rational expectations. To examine the neural basis of behavior during bubbles, we performed functional magnetic resonance imaging while participants traded shares in a virtual stock exchange with two non-bubble stocks and one bubble stock. The price was largely deflected from the fair price in one of the non-bubble stocks, but not in the other. Their fair prices were specified. The price of the bubble stock showed a large increase and battering, as based on a real stock-market bust. The imaging results revealed modulation of the brain circuits that regulate trade behavior under different market conditions. The premotor cortex was activated only under a market condition in which the price was largely deflected from the fair price specified. During the bubble, brain regions associated with the cognitive processing that supports order decisions were identified. The asset preference that might bias the decision was associated with the ventrolateral prefrontal cortex and the dorsolateral prefrontal cortex (DLPFC). The activity of the inferior parietal lobule (IPL) was correlated with the score of future time perspective, which would bias the estimation of future price. These regions were deemed

to form a distinctive network during the bubble. A functional connectivity analysis showed that the connectivity between the DLPFC and the IPL was predominant compared with other connectivities only during the bubble. These findings indicate that uncertain and unstable market conditions changed brain modes in traders. These brain mechanisms might lead to a loss of control caused by wishful thinking, and to microeconomic bubbles that expand, on the macroscopic scale, toward bust.

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Key words: functional MRI, time perspective, functional connectivity, prefrontal cortex, inferior parietal lobule, premotor area.

INTRODUCTION

The growth and burst of economic bubbles have occurred throughout history under diverse economic systems. After each crisis, governments have attempted to improve their economic systems to avoid future bubbles, but none has managed to eliminate them completely (Chancellor, 1999). This suggests that the mechanisms underlying the emergence of bubbles may not be inherent to economic systems per se, but lie in human cognitive traits that produce bounded-rational trading behavior under certain conditions.

Most existing economic theories presume rational human behavior based on the incorporation of infinite information about the real economy. However, every individual's knowledge of the world is limited and, in making decisions, people extrapolate beyond known conditions. They do this using a combination of educated guesswork, imagination, and intuition (Simon, 1947). Certain cognitive biases operate in this process, some of which have been postulated to underlie economic bubble behavior. They include the money illusion (Weber et al., 2009), in which people overestimate their purchasing power, which results in an imbalance of spending versus saving, and the Keynesian beauty contest (Coricelli and Nagel, 2009), in which people's investment is driven by expectations about what other investors think, rather than expectations about fundamental profitability. Both of these cognitive distortions have been attributed to activity in the ventromedial prefrontal cortex (VMPFC). However, the VMPFC seems to be more involved in the layered structures of present situations, such as hidden social mentalizing (Frith and Frith, 2006), rather than in the past and future.

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Abbreviations: ANOVA, analysis of variance; BI, bias index; BLB, Burst Lehman Brothers; DLPFC, dorsolateral prefrontal cortex; FA, flip angle; fMRI, functional magnetic resonance imaging; FOV, field-of-view; FTP, future time perspective; GLM, general linear model; IPL, inferior parietal lobule; LDS, large-deflection stock; MRI, magnetic resonance imaging; PPI, psychophysiological interaction; ROI, region of interest; SDS, small-deflection stock; SVC, small volume correction; TE, echo time; TR, repetition time; VMPFC, ventromedial prefrontal cortex.

Here, we hypothesized that an emerging bubble situation modulated brain activities, marking greater contemplation by the agent of the future implications of their current actions. The absence or incompleteness of data about the future means that there is little in the way of accurate forecasting to constrain optimism (Sharot et al., 2007), which triggers the associated brain areas to form a network that includes a “wishful thinking” feedback loop. The new brain mode then overrides the cognitive mechanisms that govern normal economic decision making. To test whether this conversion occurs and to investigate its neural underpinnings, we studied the brain activity of healthy volunteers while they made decisions about stock trading in situations that simulated those that either do or do not result in an economic bubble.

Subjects played a trading game on a virtual stock exchange while inside the magnetic resonance imaging (MRI) scanner (Fig. 1), and were motivated by a real financial bonus that was obtainable through their trading. Stocks were traded under three conditions (Table 1): (1) a small-deflection stock (SDS) represented a control condition in which the fair price for the stock was known, the amount of cash and stock price was balanced to represent a stable economic situation, and subjects made rational decisions; (2) a large-deflection stock (LDS) represented an economic condition similar to the SDS situation described above,

with the exception that the deflection of the stock price reflected a bubble condition and the subjects could make decisions based on price information, but with somewhat speculative motivation. These two conditions were used as positive controls that represented the normal economy; (3) Burst Lehman Brothers (BLB) represented a test condition that mimicked the changes in the stock market that occurred during the United States housing bubble, which ended with the “Lehman shock” in 2008. In this condition, the fair stock price was unknown, cash exceeding the total stock value was provided (Caginalp et al., 1998; Porter and Smith, 2003), and the transition in the stock price reproduced the economic condition that prevailed up to the Lehman shock.

EXPERIMENTAL PROCEDURES

Subjects

Fourteen right-handed healthy subjects (seven females; age range, 20–25 years; average age, 22.1 years) participated in the study, none of whom had a history of neurological or psychiatric disorders. All were novices in stock trading and unfamiliar with Lehman Brothers stock. The Third Research Ethics Committee of RIKEN approved the experimental procedure. Written informed consent was obtained from each subject before the

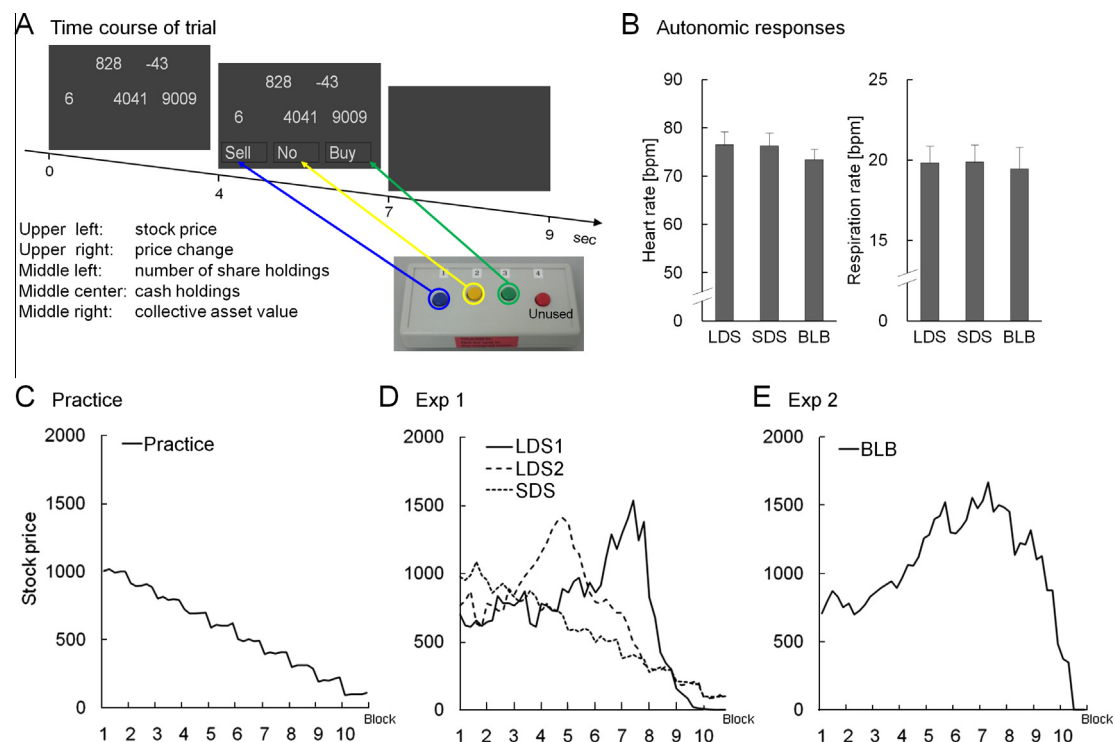


Fig. 1. (A) Time course of a trial. Stock information and asset information were presented in the upper part and the middle of the screen, respectively. Price change means the difference between the price in a trial and the price in the previous trial. The button order was assigned so that it was presented randomly in each trial. The left-to-right orders corresponded to buttons on the MRI-compatible button box (Current Designs, Inc.). The subject then pushed the button corresponding to his/her order decision. (B) Autonomic responses. Heart and respiration rates exhibited similar levels for all stocks. (C) Price series of the practice stock. (D) Time course of stock prices in Exp 1. The bubble period of one LDS was defined as extending from the fifth block to the eighth block (LDS1), and that of the other LDS was defined as extending from the third block to the sixth block (LDS2). (E) Time course of the stock price of BLB in Exp 2.

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