



# A Mind for the Market: An fMRI Study of Attribution of Mental States to Financial Markets



Antoine Bruguier<sup>1</sup>, Steven Quartz<sup>2</sup>, and Peter Bossaerts<sup>3\*</sup>

California Institute of Technology - 1201 E California Blvd, Pasadena, CA 91125

<sup>1</sup>antoine@caltech.edu - <sup>2</sup>steve@hss.caltech.edu - <sup>3</sup>pbs@rioja.caltech.edu - \*corresponding author

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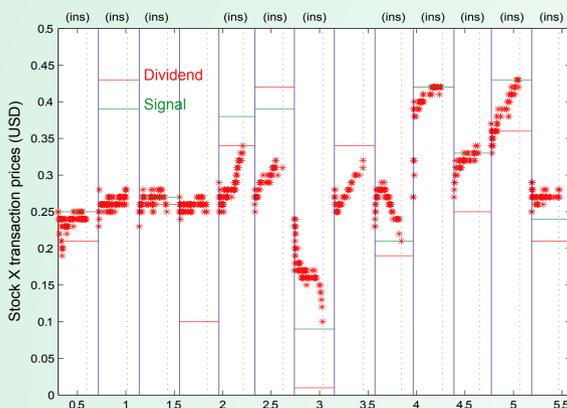
## 1. Experimental data collection

- Setup:**
- 20 subjects divided into two groups (insiders and non insiders)
  - insiders are given a **signal** (green line)
  - signal within \$0.10 of the **dividend** (red line) of a stock X
  - also add stock Z (dividend(X) + dividend(Z) = \$0.50) and a bond

- Insiders skew trades:**
- if insiders have a signal at \$0.09
  - if stock trades at \$0.40
  - then they sell stock and price goes down

- Control periods:**
- periods where there are no insider(s)

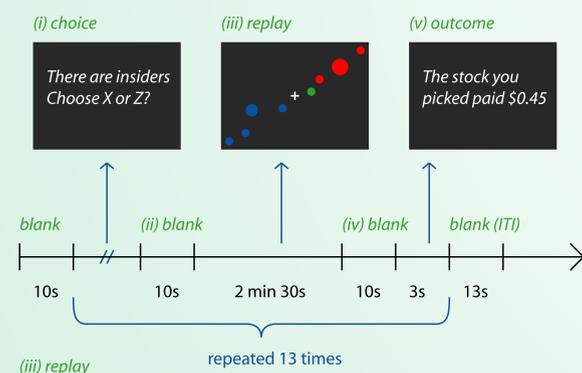
**Question:** How can non-insiders use insiders' behavior to guess signal? We hypothesize that subjects anthropomorphize markets.



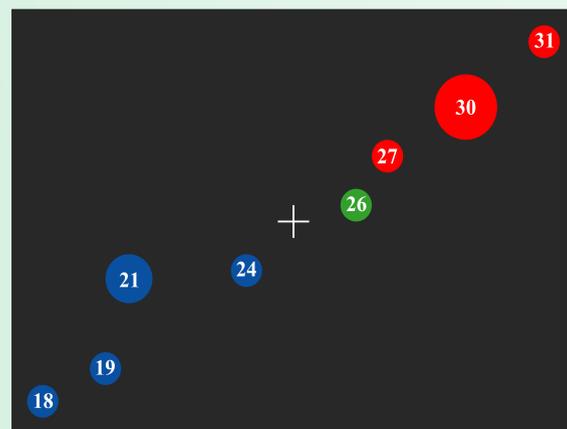
## 2. fMRI experiment

- replay all the recorded trades to 18 subjects (other pool)

- Step (i):**
- tell them whether the session has insiders
  - ask them to choose between stock X or Z



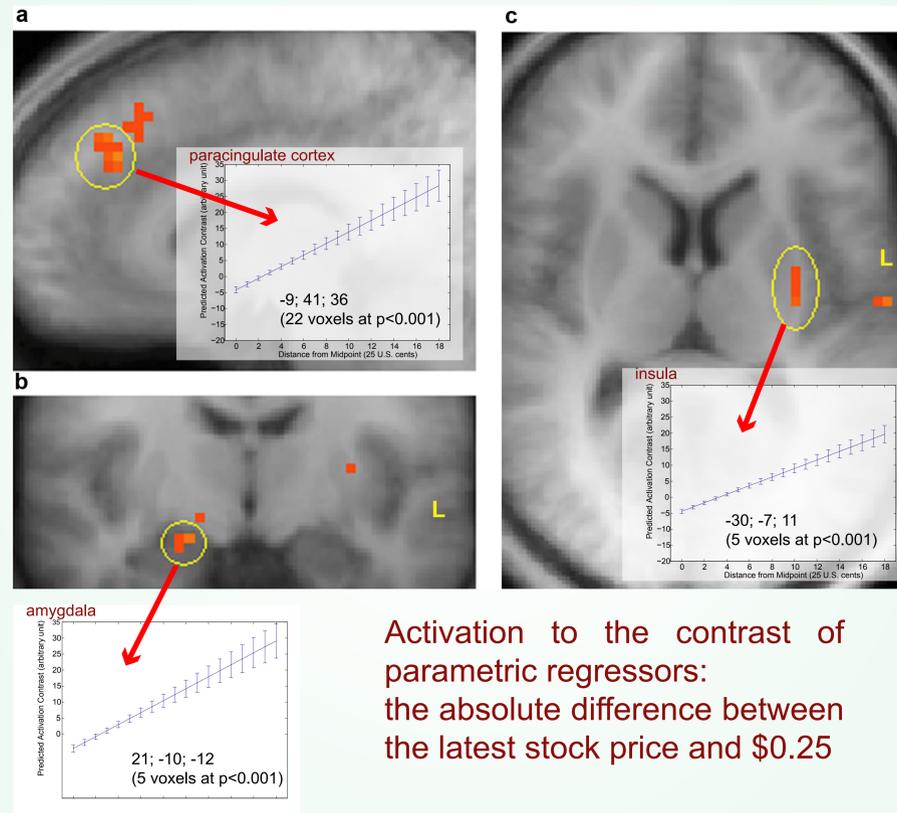
- Step (iii):**
- replay the market with moving bubbles
  - always display X
  - numbers indicate prices (cents)
  - blue/red circles are offers to buy/sell (bids/asks)
  - subjects must press key every time there's a trade (green circle for 500ms).



- Step (v):** subjects are informed of the outcome

## 3. A mind for the market

All the activations reported are the contrasts between insider and non-insider sessions. We therefore remove the influence of the traders and look at the perception of the stock market itself.



Activation to the contrast of parametric regressors: the absolute difference between the latest stock price and \$0.25

### Observations:

- theory of mind (ToM) circuitry
- modulation of the saliency of the ToM (Frith et al.)

### Paracingulate cortex activation in:

- strategic games with other humans vs. computers
- choice vs. belief expression in strategic games with humans (McCabe et al., Gallagher et al., Bhatt et al.)

### Conclusions:

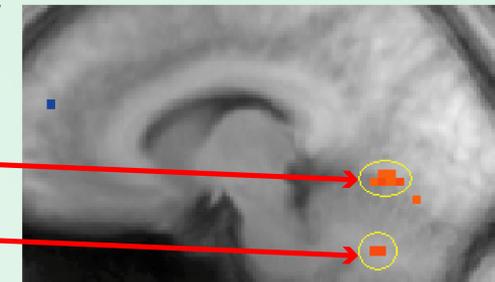
- markets not perceived like a computer that acts in a pre-programmed way
- anthropomorphization of the stock market
- against standard view of financial markets (Rational Expectations Theory, Glosten et al., Admati)

## 4. Looking beyond the trades

Activation to the contrast of block regressors: compares mean activation between sessions

**Lingual gyrus**  
-9; -65; -6  
(25 voxels at p<0.001)

**Cerebellum**  
-13; -58; -30  
(9 voxels at p<0.001)



### Do subjects use bids and asks?

- standard theory (Barner) predicts that subjects need only pay attention to trades (green circles, section 2, step (iii))
- our hypothesis: subjects use bids and asks (red and blue circles) to better understand the market

### Lingual gyrus activation:

- when extracting global meaning despite local distractors, activation of lingual gyrus (Fink et al. 96, Fink et al. 97)
- local distractor = green circle
- global meaning = entire screen

### Conclusions:

- attention to outstanding offers, not just trades

## 5. Future work

### Goals:

- detect which signals in order flow are used
- understand and predict how humans behave in a market
- find where in the brain the signals are analyzed

### Methods:

- Hotelling's T<sup>2</sup> analysis to find location of integration
- reverse correlation / ridge regression
- potentially create another experiment (coupon market crash)

## References and notes

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Videos of the stimuli available at: <http://www.hss.caltech.edu/~antoine>  
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