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## Cognitive ability and earnings performance: Evidence from double auction market experiments

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## ABSTRACT

Our goal in this paper is to understand how heterogeneity in people's cognitive ability leads to different market behavior, and thus different market performance. To do this, subjects with heterogeneous working memory capacity (WMC) were placed in a double-auction environment to compete against artificial traders. We considered two treatments which differ in the artificial traders. The artificial traders are truth-telling in the first treatment, but demonstrate adaptive trading behavior in the second one. Our results show that working memory capacity has a significantly positive effect on subjects' market performance, and the performance gap caused by cognitive ability, while narrowing over time, remains significant by the end of experiment. We find that differences in subjects' performance resulted from their behavior: high-WMC subjects were better at exploiting extra profit opportunities and avoiding unprofitable transactions, and they tended to underbid more than those with lower WMC. Among the five constituent abilities of WMC, we find that it is distinctive abilities which contribute to the overall significance in these two treatments. For the treatment involving truth-telling traders, the relevant factor is the ability of simultaneous processing and storing information; whereas, for the treatment involving adaptive traders, the only one that matters is subjects' ability to coordinate elements into structures.

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## 1. Introduction

When characterizing economic agents in the markets, the classical approach in economic theory is to assume that investors are homogeneous and rational. Models based on rational and homogeneous (and therefore representative) agent is the backbone of macroeconomic and financial theories, such as the Efficient Market Hypothesis (EMH) and the Capital Asset Pricing Model (CAPM). However, such assumptions (rational and homogeneous) about agents have been greatly challenged by empirical studies in recent decades.<sup>1</sup> Acknowledging these findings, economists have commenced an important paradigm

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E-mail address: [chungching.tai@thu.edu.tw](mailto:chungching.tai@thu.edu.tw) (C.-C. Tai).URL: <http://web.thu.edu.tw/chungching.tai/www/> (C.-C. Tai)<sup>1</sup> For example, Allen and Taylor (1990); Frankel and Froot (1987a, 1987b, 1990a, 1990b); Ito (1990), and Taylor and Allen (1992) all found that practitioners in foreign exchange markets employ different trading and forecasting strategies. Vissing-Jorgensen (2003) found that investors have heterogeneous beliefs,

shift from homogeneous and rational agent approach towards an approach where market participants are boundedly rational and heterogeneous (Hommes, 2006). For example, the most flourishing strand of research is to assume that people in the markets have different expectations (or beliefs).<sup>2</sup>

Heterogeneous agent models (HAMs) can explain stylized facts well. However, most of the models have agents differing only in their behavior, and their behavior is predetermined or depends on a mechanism which is uncorrelated with personal factors. For example, in heterogeneous expectation models, researchers have to either determine the compositions of agents or design a switching mechanism for agents to choose among different expectation heuristics. The underlying assumption of the latter is that agents are homogeneous in their tendencies toward different beliefs, or they have the same intensity of choice when choosing among different expectation heuristics. The result is that the fractions of agents is the outcome of a stochastic process and independent of agents' personal factors. Fortunately, there are increasing efforts trying to go deeper and ask whether heterogeneity in traders' behavior stems from more fundamental factors. For example, Bosch-Rosa et al. (2015) found that subjects with higher levels of cognitive sophistication predicted asset prices closer to the fundamental values.

In fact, the idea of linking behavioral heterogeneity and its economic outcomes to personal factors is not new in the history of economic thoughts. Vilfredo Pareto, who is well-known for his study of income and wealth distribution, when speculating about the causes of economic inequalities, submitted the notion of *social heterogeneity*:

“Human society is not homogeneous; it is made up of elements which differ more or less, not only according to the very obvious characteristics such as sex, age, physical strength, health, etc., but also according to less observable, but no less important, characteristics such as intellectual qualities, morals, diligence, courage, etc.” (Pareto, 1971, Chap II, 102)

In this paper, we focus on one of the factors Pareto has pointed out: *intellectual qualities*.

How do people's intellectual qualities, or cognitive abilities, affect their market behavior has been an attractive issue for many empirical and experimental economists in recent years. Empirically, by investigating people's cognitive ability and their financial portfolios, both Christelis et al. (2010) and Grinblatt et al. (2011) found that people with high cognitive ability invest more in stock markets. Specifically, Grinblatt et al. (2011) found that the stock market participation rate of individuals with IQs at the lowest end (lowest stanine) is 15.4% lower than that of individuals at the other end of the spectrum. This IQ effect is far larger than income's effect on participation. Grinblatt et al. (2012) found that high-IQ investors had better trading skills and were less susceptible to the disposition effect, and their portfolios displayed better performance results.

Experimental evidence also emerges rapidly. By comparing subjects' actual bids to the theoretical break-even bids, Casari et al. (2007) examined whether subjects suffer the winner's curse in common value auctions. They found that those whose SAT/ACT (American College Test) scores are below the median are more susceptible to the winner's curse. Bosch-Rosa et al. (2015) observed the bubble and crash patterns in experimental asset markets composed of subjects with low levels of cognitive sophistication, while no bubbles or crashes occurred in market sessions with sophisticated subjects. Cueva and Rustichini (2015) found that the higher the subject group's average cognitive skills, the lower the market volatility in an asset market. Corngnet et al. (2015) motivated subjects in asset markets with two different schemes—earned money v. house money. They found that no matter where the endowments came from, the higher subjects' CRT (Cognitive Reflection Test) scores, the more money they earned. To be more specific, subjects with lower CRT scores tended to buy shares when prices were above fundamental values, and sell shares when below the fundamental values. Breaban and Noussair (2015) had two treatments: a bear market and a bull market. They observed a significant correlation between CRT scores and being a fundamental value trader in Market 1; additionally, the greater the average CRT score, the smaller the differences between market prices and fundamental values. Noussair et al. (2016) had both a spot market and a futures market within which participants could trade. They found that the average CRT score of a trader cohort is negatively correlated with the degree of mispricing when no futures market was present, and this relationship disappeared if a futures market existed. They also found that traders with higher CRT scores had greater earnings no matter whether a futures market was presented or not.

Although the aforementioned findings are valuable, we are interested in knowing how cognitive ability influences people's trading behavior in a more fundamental way. We want to investigate whether the link exists and provide the basis for future heterogeneous agent modeling not only for asset markets but also for other market activities. Note that markets could have different pricing mechanisms and institutional factors, and trading against other market participants involves complex strategic interactions. If researchers want to understand whether inherent cognitive ability limits the benefits people can elicit from mutual exchanges, they must account for these factors. This is not an easily achievable task, however. We therefore think it is a good strategy to begin within a simple but standard environment. Based on our findings in this simple setting, economists, through continued studies, may fortify our understandings of how cognitive ability manifests its influences in people's market activities.

and Elliott and Ito (1999); MacDonald and Marsh (1996), and Bénassy-Quéré et al. (2003) found that trader's expectations are also heterogeneous in foreign exchange markets.

<sup>2</sup> Examples of heterogeneous belief models include Brock and Hommes (1997a, 1997b, 1998); Bullard and Duffy (1999); Chiarella and He (2002); Chiarella et al. (2006, [2007,2013,2015]); Chiarella and He (2001, 2003a, 2003b); Chiarella et al. (2012, 2009); Day and Huang (1990); Franke and Ne-semann (1999); Franke and Sethi (1998); Gaunersdorfer (2000); Hommes (2001); Hommes and Lux (2013); Lux (1995, 1997,1998); Lux and Marchesi (1999, 2000); Sethi (1996).

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