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On the neural substrates of the disposition effect and return performance

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ABSTRACT

We experimentally assess the disposition effect and return performance, using electroencephalogram to measure the brain activity of the participants. The design of the experiment follows a previous protocol (Frydman et al., 2014). Our sample was made up of 12 undergraduates (all male, age range 18 to 29, mean age 22.2) and five professional stock traders (all male, age range 21 to 37, mean age 30.2). We further considered the total of purchases and sellings of each participant, which renders us with an enlarged sample of 164 observations. This alternative metric fits well for incorporating the neurophysiological variables. We find neural support for the finding that professionals are more likely to escape the disposition effect. We also find higher heart rate variability and brainwave activation are positively related to stock returns. Electrical activity tends to increase with returns, mainly for the beta waves that are activated in conscious states.

1. Introduction

In current economics and finance, bounded rationality is an assumption of financial behavior that coexists with that of full rationality. Historically, full rationality was challenged by the experimental discoveries initiated in the 1980 s within the research on behavioral finance (Heukelom, 2014). One such well-documented finding was the disposition of stock traders for selling winners rather than losers. The anomaly has received an opaque label: the disposition effect. That is, the disposition to sell winners too early and ride losers too long (Shefrin and Statman, 1985). The discovery meant investors are reluctant to realize their losses (Odean, 1998). Many explanations have been proposed but none is established. An obvious account that can be accommodated with full rationality is plain mean reversion. An investor keeps losing stocks just because he or she rationally guesses the stocks will gain in value in the future. However, bounded rationality is more generally accepted to lie at the heart of the disposition effect. Here, there are many hypotheses that share the understanding of the disposition effect as a cognitive bias. "Prospect theory" was an early candidate, but even its proponent now favors the so-called "narrow framing hypothesis" (Kahneman, 2011). An investor sets up an account for each share he or she bought, and wishes to close every account as a gain. The rationale of mental accounting is bounded because a full rational attitude is to consider the portfolio as a whole and sell the stock that is more likely to underperform in the future, regardless of whether it is a winner or a loser.

The neural substrates of financial biases, such as the disposition effect, can be assessed by the complementary, emerging field of neurofinance (Sahi, 2012). Neurofinance examines experimentally the nature of the cognitive processes engaged in acquiring and processing information in financial decision making. Financial decisions are analyzed by applying neurotechnology to observe and understand neural traits affecting trading and their possibly associated biases. Neurofinance assumes investors have different psychophysiological make-ups, and these can affect the investors' ability to make full rational decisions in investing (Tseng, 2006).

The neural data coming from neurofinance experiments can be helpful in testing models of investor behavior (Frydman et al., 2014). A recent study confirmed the disposition effect is due to bounded rationality, but not of the narrow framing type (Frydman et al., 2014). The authors conducted the study in an experimental market where participants traded stocks while their brain activity was measured using functional magnetic resonance imaging (fMRI). There emerged neural evidence that investors derive utility directly from realizing gains and losses on the sale of stocks

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they own, in addition to deriving utility from consumption (a hypothesis called "realization utility" (Barberis and Xiong, 2009). Importantly, the neural data also cast doubt on the mean reversion hypothesis.

Here, we experimentally reassess the disposition effect adopting the neurofinance perspective (Frydman et al., 2014), but measure brain activity with electroencephalogram (EEG) rather than fMRI. EEG is usually employed to track electrical activity in the brain. Brain cells communicate with each other through electrical impulses and an EEG test can record them. Thus, EEG detects brain wave patterns. Further, we consider the disposition effect at the behavioral level as well as the neural level (Frydman et al., 2014). And we also try to replicate previous findings regarding the disposition effect at the psychophysiological level (Goulart et al., 2013). Our study is nuanced by the distinction we make between professional investors and amateurs. At the behavioral level, professionals were shown more likely to escape the disposition effect (Da Costa et al., 2013), a result that receives neural support from our experimental data.

Despite being published as recently as 2014, the paper of Frydman et al. has already received 90 citations, including ours. Using their evidence that investors trade based on a specific portion of wealth in isolation, Hartzmark (2015) documents a new stylized fact termed "the rank effect", which refers to the finding that the best and worst-ranked positions are more likely to be sold compared to positions in the middle of the portfolio. However, it has been warned that discontinuity tests on U.S. investor trades do not support sign realization preference, and show that it is not the source of the disposition effect (Hirshleifer, 2015; Ben-David and Hirshleifer, 2012). Moreover, Clarke (2014) criticizes the neurofinance approach of Frydman et al. (2014) on methodological grounds by pointing to a simple modus tollens, disrupting their argument. Their first premise is that an economic model entails a specific cognitive hypothesis. One then learns, using neurofinance data, that the cognitive hypothesis is false. So, one must conclude that the content of the economic model is also false. However, because economic models of decision making do not entail specific cognitive hypotheses when they are construed appropriately, the first premise of the above argument is false (Clarke, 2014). Rather than aiming to prove or disprove alternative explanations of the disposition effect, here we only investigate whether it emerges in our neural data, regardless of the mechanism that generates it.

The next section presents the materials and methods of our study; Section 3 displays the results found; and Section 4 concludes the report.

2. Materials and methods

2.1. Participants and sample

We assembled a sample of 12 undergraduates (all male, age range 18 to 29, mean age 22.2) and five professional traders (all male, age range 21 to 37, mean age 30.2). The students came from the Federal University of Santa Catarina, Florianopolis, in southern Brazil. They were undergraduates enrolled in economics, accounting or management. The professionals also came from the Florianopolis area. This seems like a small sample for behavioral studies, but for most neuro studies it cannot be considered uncommon because, it is argued, adding more participants usually does not seem to alter results a great deal (Bhatt and Camerer, 2005). The participants were all right-handed, had no history of psychiatric illness and none were taking medication. The students reported no previous financial market experience. Homogenizing the sample according to these characteristics provides reliability concerning the particular results generated from the neuro and physiological output. The downside is that the sample is hardly random. Instead, the behavior of the participants is likely to overstate that of a random population. All the participants read the purpose of the experiment and then signed a term of consent. The research received approval from the Ethical Committee for Research on Human Beings of the Federal University of Santa Catarina (case number: 1.744.242; date of approval: September 26, 2016). The dataset is available at Figshare (https://dx.doi.org/10.6084/m9.figshare.4312091.v1).

The sessions for data collection were conducted at the Brain Education Lab at the Federal University of Santa Catarina, under the supervision of the lab director (author E.T.). The sessions took place during the morning and the chronotype characteristics of the participants were thus ignored. The room temperature was kept constant at 24 °C. Prior to the sessions, the experimenter (author A.D.) gave a questionnaire to collect information regarding age and whether the participant had previous experience with stock trading, whether he was taking medication, and whether he has a history of illness or brain damage. The session durations ranged 15 to 60 min.

2.2. Measuring neural activity

To measure the neural activity, we employed the ProComp Infiniti System with BioGraph Infiniti Software (T7500M) from Thought Technology Ltd. The ProComp Infiniti is an eight-channel, neurofeedback and biofeedback system for real-time data acquisition in a clinical or research setting. We used the channel appropriate for viewing the EEG and concentrated on the alpha and beta brainwaves. We only considered data with 100% quality signals.

The communication between neurons within our brains underlies all our thoughts and emotions. Synchronized electrical pulses from neurons communicating with each other produce brainwaves that can be detected using sensors placed on the scalp. The brainwaves are divided into bandwidths to describe a continuous spectrum of consciousness: from slow, loud and functional to fast, subtle and complex. Brainwave speed is measured in hertz (Hz), which means cycles per second. The brainwaves change according to what one is doing and feeling. In particular, alpha waves (8 to 12 Hz) occur during quietly flowing thoughts and refer to the resting state of the brain. Alpha waves help mental coordination, calmness, alertness and learning. Beta waves (12 to 38 Hz) are present in the normal waking state of consciousness when one is alert, attentive, and focused on problem solving, judgment, and decision making.

The equipment was equipped with a 60 Hz filter that automatically removed electrical interference from the room's electric power. ProComp Infiniti offers no risk of electrical shocks.

2.3. Measuring heart rate activity

We measured the heart rate using the EKG (electrocardiogram) channel of the ProComp Infiniti equipment. Normal heart rate produces four waves: a P wave, a QRS complex, a T wave and a U wave. The P wave represents atrial depolarization; the QRS complex represents ventricular depolarization; the T wave represents ventricular repolarization; and the U wave represents papillary muscle repolarization. In particular, the QRS complex corresponds to the depolarization of the right and left ventricles. It normally lasts from .06 to 10 s. The Q, R and S waves occur in succession and reflect a single event. A Q wave is a downward deflection after the P wave. An R wave follows as an upward deflection, and the S wave is a downward deflection after the R wave. The T wave follows the S wave. In some situations, an extra U wave follows the T wave.

One of the variables we measured was the RR interval, that is, the time interval in milliseconds between two R waves. Our choice is justified by the fact that the RR interval produces a

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