



# How Investor Sentiment Impacts Financial Decision-making Behavior: From A Cognitive Neuroscience Perspective

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## ABSTRACT

In financial markets, irrational behaviors of investors are an important driver of the noise market, and such irrationality is fueled by changes of sentiment of investors. Then how the investor sentiment impacts their financial decision-making behaviors? First, this paper, from a cognitive psychological perspective, explains the mechanism of how investor sentiment and market sentiment are developed; secondly, based on a method of cognitive psychology and neuroscience, we build the models on how investor sentiment impacts risk decision and intertemporal decision. This paper concludes that the investor sentiment is a result of conflicting perceptual analysis and cognitive processing, and it further develops into market sentiment through “information adverse filtering” and “unification of belief”; these sentiments exert implications on the risk decision and intertemporal decision through emotional processing and situational force.

**Key Words:** Sentiment, Emotional Processing, Situational Force, Risk Decision, Intertemporal Decision

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## Introduction

Investor sentiment is a basic concept of behavioral finance and represents the irrational behavior of investors (Lucey and Dowling, 2005). The definition of sentiment, according to Sadock (2000), is the subjective and direct psychological experience formed by individuals on an event or situation. It is one of the 16 major topics in the decision-making area (Hastie, 2001). In earlier researches, sentiment was treated as an interference in the decision-making process. With the development of cognitive and neuroscience, the researchers came to realize that, in the process of decision-making, sentiment, just like rational cognition, is a necessary source of information input. Further with the development of behavior finance, the previous research has introduced the

theories of subjective expected utility as well as disappointment and regret to the research of prospect theory. Along with this, it was realized that investor sentiment, in a volatile market, has become a driving factor that governs transaction behaviors. Standard finance supports that financial decision-making of investors is a result of the “trade-off between risk and return”. But in the real-world business, we see in the financial markets many anomalies that are against this principle, such as “mystery of equity premium” and “calendar effect”, contradicting with the hypothesis of investor as a “rational person” and making the justification hard. As the area of behavior finance further develops, the academia realized that sentiment causes cognitive limitations and misjudgment. It then led to

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cognitive and behavioral biases that affects financial decision-making and decisions made (Baker *et al.*, 2004). Then what constitutes the physical basis and objective logic for such relation? It is hard to provide an answer with economic theories or methods. The introduction of cognitive neuroscience opens up a new chapter for this area of research. As we know, the cognitive neuroscience is a synergy of cognitive science and neuroscience, an emerging subject widely recognized in the worlds' academia world since the last century, and a front-end area with the very promising prospects. This method combines the strength in brain mechanism as a cognitive research area and in psychology so as to serve as an objective research method.

**Formation mechanism of investor sentiment - explanation based on emotional arousal model**

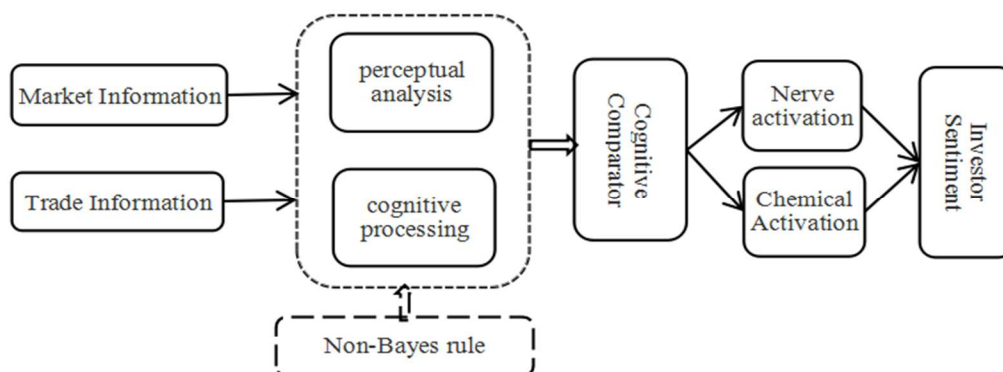
When finance research measures investor sentiments, there are a variety of indicators, for example, the discount factor fluctuation (Mehra and Sah, 2002) and speculativeness (Baker and Stein, 2004), pessimism/optimism in stock market expectation (Brown *et al.*, 2007), but there are some disputes since the economics theories are not good solutions to the determination of the formation mechanism of investor sentiment. Based on the above-mentioned definition, sentiment is subjective impression of individuals on events and situations. This impression is result of a brain mechanism on comparing real-world result against external information after simple

processing based on the individual's own memory and experience. So, sentiment fundamentally results from a cognitive process, physiological process and environment factors acting on cerebral cortex.

Lindsay and Norman (1977) set up three steps of formation of sentiments in their emotional arousal model, i.e., perceptual analysis, cognition process, and cognitive comparison of the two. In the first step, investor obtains relevant information, such as the company fundamentals, market liquidity, information disclosure, turnover, and transaction price. Due to investor's physiological features, it is difficult for them to process all the information (Ji, 2008). An investor tends to simplify complex information based on heuristic principle and acts as a "cognitive miser". This method allows them to gain an overall impression of the subject in a short time. Here the impression is an innate instinct. For example, in coin-tossing, the probability for it to land on heads for one time is 1/2, and 1/256 if eight times. If it lands on heads for eight times straight, will you bet on it to land on hands again for the ninth toss? What is the probability? Out of habitual thinking, people tend to believe the probability will further decrease to 1/512, and dare not to bet on a ninth toss for heads. But the actual probability is still 1/2. This mind-set prevents investor from collecting all information for objective analysis and calculations like a "rational person". This is how the Bayes theorem works in decision-making.

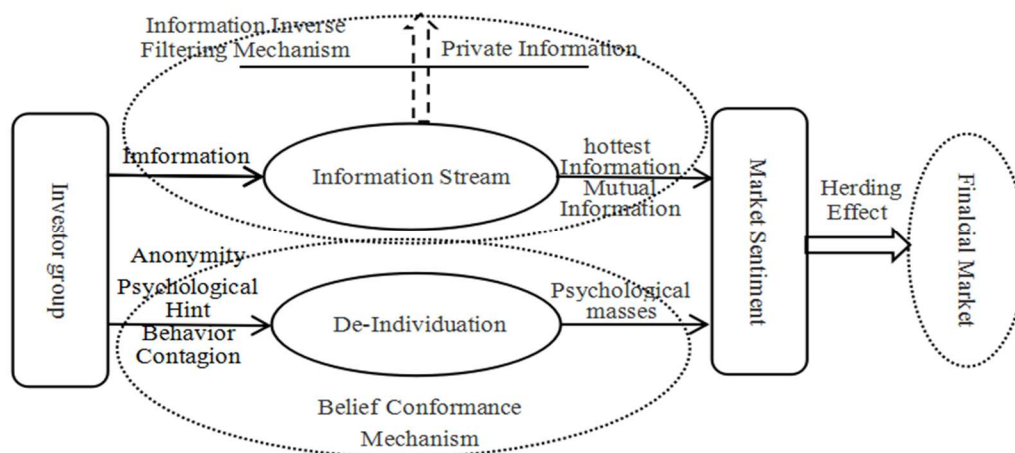
**Table 1.** Cognitive Experiment

The number of H	H	HH	HHH	HHHH	HHHHH	HHHHHH	HHHHHHH	HHHHHHHH
	1/2	1/4	1/8	1/16	1/32	1/64	1/128	1/256



**Figure 1.** Investor sentiment formation mechanism based on emotional arousal model





**Figure 2.** Mechanism of market sentiment formation from “information adverse filtering” and “unification of belief”

In the second step, investor performs cognitive processing on the available information. In terms of cognitive process, it means the model an individual processes the information based on his/her own experiences. In financial markets, investor performs cognitive processing under a non-Bayes rule on available information based on the experience and rules formed over a long term of transaction activities, for example, observing market liquidity from a perspective of turnover, measuring stock value with PE ration, as well as predicting further prices using K lines and graphs. This is the representation of so-called “rational cognition”. In the third step, investor conduct representation comparison of perceptual analysis and cognitive processing in cognitive comparator (Lindsay and Norman, 1977): in the case of inconsistent representational results, the human cerebral cortex (including neocortex and archicortex) is stimulated, triggering strong neuro activations and chemical activations and generating strong investor sentiment consequently.

**Analysis on formation of market sentiment – explanation from “information streaming” and “deindividuation”**

“Information streaming” and “deindividuation” take effect in this process among the groups of investors. The individual sentiment interacts among the investors and develops a group effect through the mechanism of “information streaming” and “deindividuation”, thus forming a market sentiment. Firstly, the financial markets have a high level of uncertainty. Discrepancy arises when investors interpret market information with their own perceptual analysis

and cognition processing. Among groups of investors who have features in common, such as investment experience, culture and belief, or income distribution, this discrepancy is homogenized, thus forming systematic discrepancy and “information streaming” (Stasser *et al.*, 1989). When investors make decisions, they tend to value other investors’ behavior more than processing information they have for themselves. So a great amount of information privately known to investors cannot be communicated effectively among the investor groups, therefore the mechanism of “adverse information filtering” works: investors of a group tend to pay more attention to the hot spot information and common knowledge and disregard privately held information, thus the cognitive overload. For example, limited attention (Shiller, 1999) explains investors’ frenzy over a certain stock out of only limited information in financial markets. Here, individual sentiment has developed into group sentiments among investors.

Secondly, in the scenario of group sentiment, there are three features to individual behavior, anonymity, suggestibility and behavioral infectivity. Individuals are easily influenced by the common belief of a group and vulnerable to the loss of his or her consciousness of personality, which is known as anonymity and deindividuation. Under the effect of suggestibility and anonymity, investors would only follow the hot spot information and their belief and emotions would sympport, contributing to the formation of psychological crowd. This is known as the mechanism of “unification of belief” (Shiller, 1999). High uncertainty is a fundamental feature of the financial market. When facing the choices of



so many financial products, investors must make decisions based on what information they have and need to pay for high costs of information processing. Based on the balancing of information cost and return, following the other investors seems to be a “rational” choice, and over time investor would lose his own investment style. In the meantime, under the pressure of a group scenario, investors are more vulnerable to the implications of the hot spot information shared in the group and lose sight of their own information, forming a herding effect of investor behavior. Also, even if a great amount of information pose potential risks, stimulated by profits, investor tend to neglect the alarms set by objective information and keep consistent with other investors by opening and expanding the position. Eventually, this leads to the frenzy of “over pricing and over ordering”.

### **Implications of investor sentiment on financial decision-making – explanation from cognitive and neurosciences perspectives**

#### *Neural basis of financial decision-making*

Decision-making is an important part of human activities. When investors have so many choices of financial products with varied return and risk features to choose from, how do they make the decision? In line with the classic finance theory, investors should make optimal decisions based on the hypothesis of “rational person” and the principle of maximum of intertemporal utilities and the profit and probability analysis of financial assets. But in the real world, financial anomalies, such as “calendar effect” and “mystery of equity premium”, cannot be properly justified with standard finance theories. With the development of Cognitive Neuroscience, the researchers are starting to look at the cognitive neuroscience mechanism in financial decision-making in order to explain the investors’ behaviors. Research shows that the brain has a neural circuit in charge of decision-making behaviors, including anterior cingulate cortex, orbitofrontal cortex, amygdala, and striatum. Each part has different roles to play in the process of decision-making. Financial decision-making in fact is a selection made based on the return and risk features of asset, including three behaviors calculation of expected return, assessment of financial risk, and prediction of decision result. Firstly, the calculation of expected return has strong stimulations on the activity level of ventral striatum, the medial prefrontal cortex area (Sanfey, 2006; Knutson *et al.*, 2008); secondly, assessment of financial risk has

significant impact on the activity level of ventral striatum, the lateral prefrontal cortex area, and posterior parietal lobe (Dreher *et al.*, 2005; Weber *et al.*, 2008); besides, the activity of the anterior insula activation, nucleus accumbens activity, on both sides of the top and left insula lobe is subject to influence of projection activity after financial decision is made (Bartra *et al.*, 2013; Rudebeck *et al.*, 2013).

#### *Implications of investor sentiment on financial decision*

The classic finance theory believes that financial decision-making is an information processing system where the external environment is the source of information and investor cognition processing provides support for decision-making. Sentiment is a result of interactions among the environment, physiology and cognition (Schachter, 1962). “Information adverse selection” disturbs the information source of external environment, while “unification of belief” exerts subjective implications on the cognitive processing. For this reason, sentiments has substantive effects on cognitive processing of information via situational force and sentiment processing. The situational force means that under the impact of group consciousness and physical environment, sentiment influences the information acceptance of investors. Gold and Colleagues (2000) conducted selection experiment while the subjects is situated in cold light and warm light. The experiment shows that subjects act with higher degree of irrationality when they are in the warm light than in the light night. Sentiment processing means that in the process of cognition processing, the subject’s emotions interfere with the cognition processing, hence implicating the decision-making behavior of the subject. Moretti and Pellegrino (2000) also demonstrated through experiment that, when making decisions with declining profits, the subject tends to disapprove the decisions under the influence of sadness; while when in stable states, the subject’s disapproval of decisions winds down.

#### (1) Implications of investor sentiment on risk decision

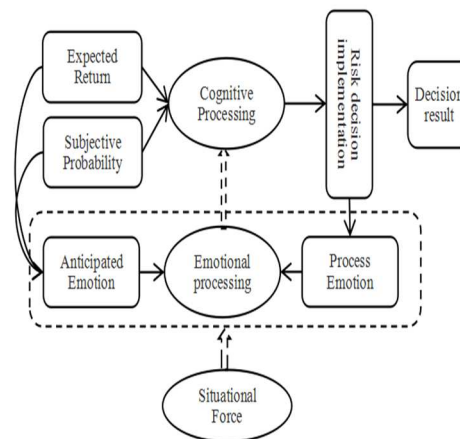
Financial decision has two types, risk decision and intertemporal allotment decision. Financial risk decision means in an environment with uncertainty, investor makes judgement of the cost and return and arrives at a decision based on





judgement of expected return and subjective probability determination. Its neural mechanism is closely related to the amygdala. When there is threat or danger, the amygdala constantly scans the information source, and supports the decision-making of the brain with cognition processing and emotional processing.

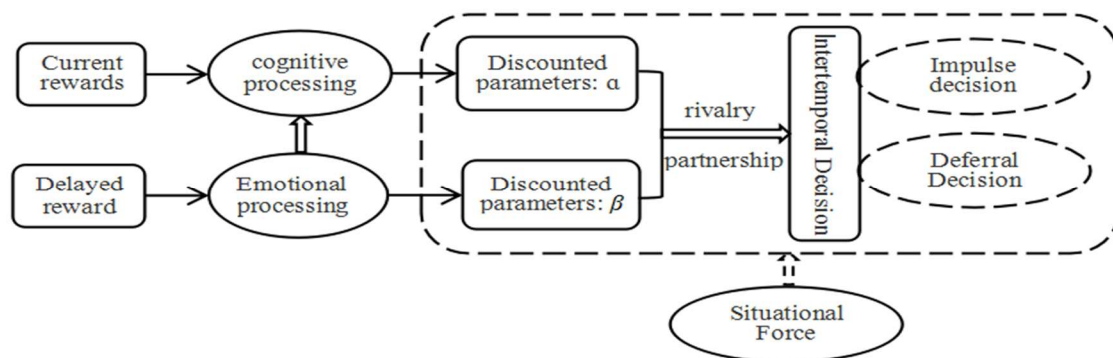
According to the “risk sentiment model” of Loewenstein (2001), sentiment has strong influence over risk decision. When there is higher level of uncertainty and difficulty, the influence of sentiment on decision-making also improves. A cognitive neuroscience research on risk decision-making on the case of Iowa gambling shows that when people are dealing with simple and easy tasks, they adopt the low emotional arousal strategy, i.e., emotional processing has low impact on cognition processing; while when dealing with complicated and complex tasks, people tend to adopt the high emotional arousal strategy, meaning the information source of emotional processing plays a dominant role in the task. Due to fast development of the financial market, the varieties and scales of assets are increasingly diversified. In the meantime, the implications of the investor sentiment and market sentiment on decision-making behaviors are also noticed. This paper divides investor sentiment into two categories: the expectation sentiment and process sentiment. Expectation sentiment means sentiment generated from expectations on the decision results, for example, the joy one feels when the expected profit exceeds expected cost; and the latter means sentiments generated from the process of decision-making, for example, depress and fear when market is underperforming than expectation. Emotional processing interferes the implementation of decision-making with expectation sentiment, thus forming “emotional attribution bias” (Lucey and Dowling, 2005): in a positive mood, positive decision is made, and a passive mood hurts the proactivity of an investor. For example, investor’s assessment of a company’s value is highly dependent on his or her impression of the company, even of its name (Cooper *et al.*, 2001); the process sentiments on the other hand lead the customer to adjust its decision behaviors, such as when market is staggering, investor has shattered confidence and is full of fear so that he or she sells out the stocks in advance (Lee and Andrade, 2011).



**Figure 3.** “Investor sentiment – risk decision-making” model adjusted from Loewenstein (2001) model

Similarly, the situational stress is a source of sentiment implications on financial decision-making. When investor is in a situation with a lack of information or high degree of information asymmetry, or other uncertainties that undermine expected profit, the individual sentiment is easily stimulated, thus interfering with decision-making. This is because under this situation, limited amount of information does not support sufficiently investor’s cognition processing. In addition, in the process of emotional processing, sentiment can easily provide additional “information” to impact the decision-making behavior. On the other hand, the situational stress results in discrepancy of expectation result from the cognitive processing result, which further induces generation of sentiments and implication on decision-making behaviors of the investor, hence a spiral relationship. Damasio (1994) found out through experiment that investors tend to see the expectation results as an important information source, when they are conducting result expectation and sentiments are generated. For example, Casti (2010) discovered that passive social phenomena leads to higher level of terrorist activities. The fluctuations of markets, such as rise, fall, valley and peaking, generate market sentiment features common among the investor groups, i.e., a “sell into corrections” phenomena. Olson (2006) summarized this situation in a “valence-activation” model of sentiment. Adapted from the “risk-sentiment model” of Loewenstein (2001), and based on sentiment processing and situational stress, this paper adjusts the model into an “investor sentiment- risk decision” model which interprets the investor’s “expectation sentiment” and “process sentiment”.





**Figure 4.** “Investor sentiment – risk decision-making” model adjusted from Quasi-Hyperbolic Discounting model

(2) Implication of investor sentiment on intertemporal decision-making

Intertemporal decision means the allotment decision of financial resources made by an investor at varied timing. Based on Quasi-Hyperbolic Discounting model, intertemporal decision is made by investor in terms of selection of discounting rate in order to realize the maximum utilities of financial resources over a period of time (Loewenstein, 2001). It seeks a balance between short-term return and long-term return. In the Quasi-Hyperbolic Discounting model, the discounting rate demonstrates attenuation involving two parameters, namely  $\alpha$  and  $\beta$ .  $\alpha$  is the rational discounting rate in classic finance theory which is finalized after cognition processing of information; while the latter is a result after sentiment processing.

This paper assumes two decision models for determination of implication of these two parameters on intertemporal decision: “impulsive decision” and “delayed decision”. The former means the investor prefers small and immediate rewards, while the latter means the investor prefers large and delayed rewards (Kalenscher *et al.*, 2006). In “impulsive decision”, these two parameters has a competitive relation. The human instinct is for seeking survival and reproduction, which stimulates current consumptions. So the discounting rate of emotional processing  $\beta$  represents over-valued utility level of current consumption, which has a competitive relation with the cognitive processing parameter  $\alpha$ . When the former is larger than the latter, investor tends to consumer rather than invest. In “delayed decision” model, the discounting rate of emotional processing  $\beta$  prefers future consumption and forms a collaborative relation with the cognitive processing parameter  $\alpha$ . It means encouraging investment and delaying consumption. Self-

controls on parsimony, anxiety, workaholics make parameter  $\beta$  overvalue the future utility and force the investor into immediate consumptions. On the other hand, situational stress is also an important factor to reflect change of discounting rate  $\beta$ . With the changes of environmental stress, group consciousness and tasks, the rate of  $\beta$  after emotional processing also changes, thus impacting the competitive/collaborative relation between the two parameters. For example, for two incomes of the same current value, an unexpected income and a fixed cash income, investor tends to adopt “impulsive strategy” on the first income, and “delayed strategy” on the second income. The underlying reason is that the sources of incomes are different, resulting in different discounting rates of  $\beta$  after emotional processing. A second example is the mystery of high saving rates for a long term in China, meaning the increase of savings way exceeds the increase of income. It may indicate that the residents place high reliance on the national credit, and is also related to the memory of long-term poverty and starvation and insufficiency of social security system.

**Conclusions**

Compared to the classic finance theory, cognitive neuroscience analyzes the implication mechanism of “investor sentiment – financial decision” from the perspectives of psychology and brain mechanism. It lays solid foundation of future development of behavioral finance. This paper first discusses the formation mechanism of individual investor sentiment and market sentiment using the “sentiment arousal model”, “information adverse filtering” and “unification of belief”, and explains the root causes of formation of sentiments when brain mechanism reacts to perceptual processing and cognition processing.



Information loss and unification of belief among groups are important factors behind the formation of market sentiment. Secondly, the “investor sentiment – risk decision” models after adjustment from the Loewenstein (2001) model and Quasi-Hyperbolic Discounting model show that the personal emotional processing and situational stress are two important ways that affect financial decisions of investors under influence of sentiment. The above conclusion provides a reliable research method for future work. For example, the sentiments can be positive sentiment or negative sentiment. Do they have the same emotional processing and situational stress? Do they exert similar ways of implications on risk decision and intertemporal decision of investors? These need to be further addressed.

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