Behavioral Finance: Contributions of Cognitive Psychology and Neuroscience to Decision Making

James A. Howard
University of Maryland University College

This paper employs a five-paradigm model to assess various contributions of cognitive psychology and neuroscience to understanding financial decision making. Whereas conventional academic finance emphasizes financial theory, the emerging field of behavioral finance *encompasses investigations of cognitive and emotional factors affecting the financial decision making processes of individuals, groups, and organizations. It looks at how people really make financial decisions, not at how theory predicts they should make such decisions. Behavioral finance expands our understanding of financial decision making in terms of personal financial decisions and how markets work but also comprises a new instrument in the decision maker's toolbox.*

INTRODUCTION

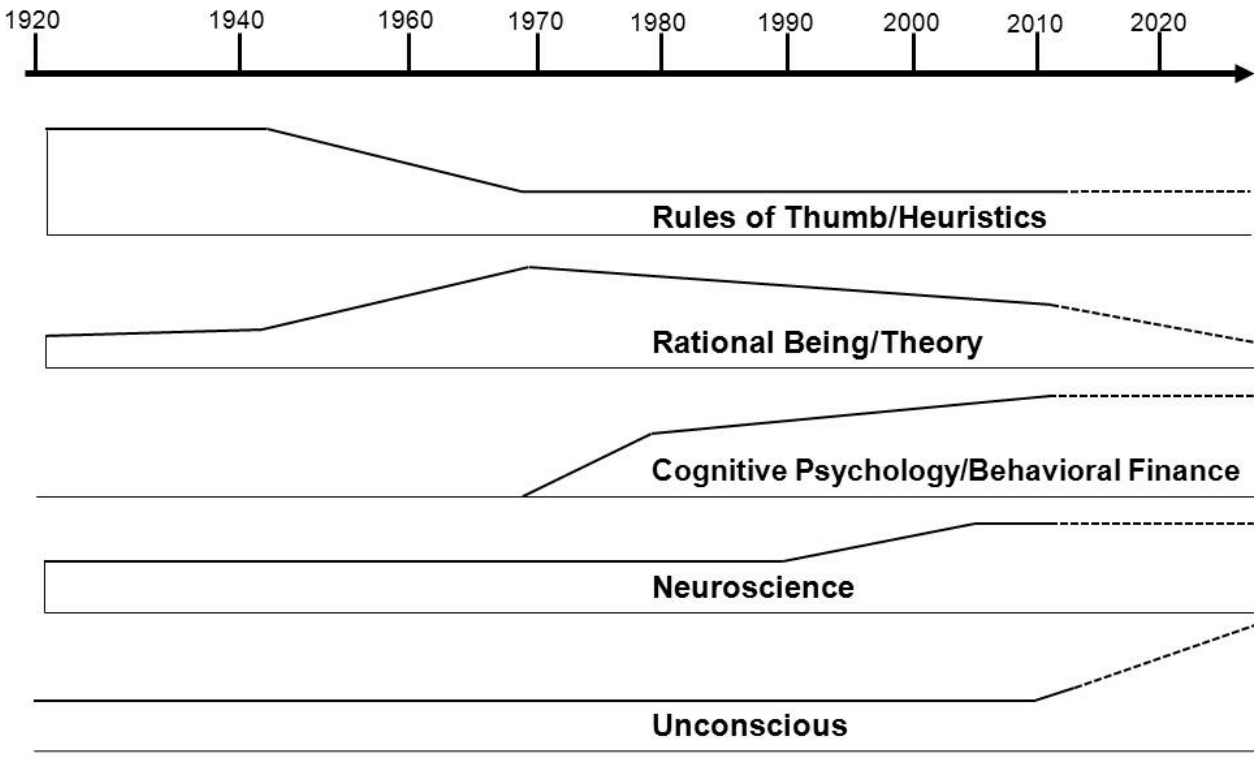
Observations in the past few years of the outcomes of financial decision making by individuals has provided a new awareness (and humility) regarding the inadequacy of the accumulated knowledge that supports sound financial decision making. Actions by Congress providing incentives for individuals to make ill-advised home purchases, home owners using their homes as ATMs to increase near-term consumption, the failure of Americans to save sensibly for retirement, poor investment performance by individual investors, and poor decision making by corporate managements that have destroyed huge amounts of wealth beg the question: Why do we get such consistently poor results and how can we improve financial decision making in the future for the benefit of stakeholders?

To respond to this challenging question, an important starting point is developing a historical context describing and analyzing how financial decision making has evolved over time. This context, when combined with an assessment of where we are in understanding financial decision making, can lead us to a deeper understanding of how to use what we know more effectively and to better define what sort of research program is needed going forward to fill the gaps in our understanding. In this paper a model comprised of five financial decision making paradigms will be employed for conducting a qualitative meta-analysis of the current state of financial decision making behavior. The five paradigms are Rules of Thumb/Heuristics, Rational Being/Theory, Cognitive Psychology/Behavioral Finance, Neuroscience, and the Unconscious.

In the last 100+ years varying amounts of research has been conducted to improve financial decision making. In general, it appears that, as each then-current most-favored paradigm becomes increasingly encumbered with anomalies and unfavorable critiques, a new paradigm arises by being able to explain some of the weaknesses of the "old" paradigm and as new areas of research are opened up. The old paradigm declines and the new paradigm becomes increasingly adopted and applied to real world

observations. At the point of maximum enthusiasm, a reductionist tendency leads us to feel that finally we may have some important solutions and henceforth financial decision making will be significantly improved. The cycle continues as this currently favored paradigm reaches its maximum influence and begins to decline due to its failures to account for observed behaviors, while a new paradigm takes its place as the one now favored to move knowledge of financial decision making forward. The model employed in this paper will attempt to show how five paradigms for financial decision making have risen to prominence over time, and how the earlier ones have leveled off and/or declined in relevance due to these forces. The overall model is shown in Figure 1:

FIGURE 1
KNOWLEDGE ACCUMULATION/EVOLUTION – FINANCIAL DECISION MAKING

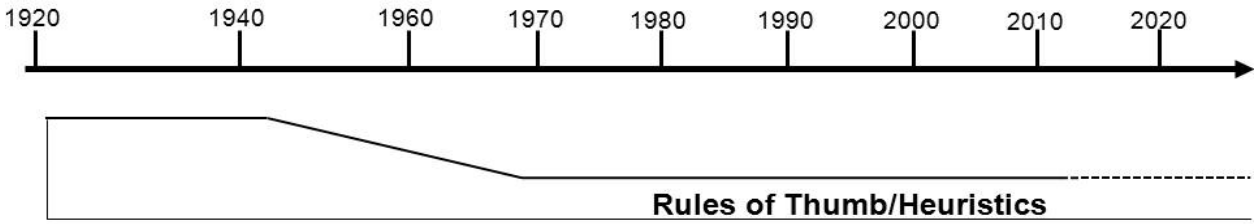


Each of the five components of this model will be described, analyzed, and assessed in terms of its contribution to the body of knowledge regarding financial decision making. The height of each curve in Figure 1 represents its relative influence as a paradigm at the indicated points in time. The examination and analysis will be on both a time series (how a specific component/paradigm has evolved over time) and cross sectional basis (how paradigms contribute to the body of knowledge at specific points in time). This qualitative meta-analysis approach is meant to provide an integrated view of contributing paradigms over time with the goal of providing more transparency to the very complex process of how financial decisions are made. Due to their strong influences on current financial decision making theory and practice, cognitive psychology and neuroscience contributions will be addressed in detail. With better awareness of what we know and what we don't know, it is hoped we can move the research forward to develop better financial decision making practices in the future.

RULES OF THUMB/HEURISTICS PARADIGM

If we go back to the time before the development of financial theory post World War II, financial decision making was heavily influenced by rules of thumb or heuristics, as depicted in Figure 2. These dominated decision making theory for about 20 years.

FIGURE 2
RULES OF THUMB/HEURISTICS PARADIGM LIFE CYCLE



Rules of thumb/heuristics are simply mental shortcuts. Gigerenzer and Wolfgang (2011) provide a definition of heuristics for the purposes of this paper: "A heuristic is a strategy that ignores part of the information, with the goal of making decisions more quickly, frugally, and/or accurately than more complex methods" (p. 454). Thus, heuristics do not attempt to find the optimal solution but one that is best given the context and constraints faced by the decision maker. The case against heuristics is that because heuristics are using mental shortcuts, they are inferior to more comprehensive approaches.

Certainly, using heuristics is not the best approach in every case, but when applied appropriately, they represent the best a decision maker can do in specific situations given the tradeoff between time available to make a decision, uncertainty, and the cost of getting better information. In a situation where there is little uncertainty, adequate information, and sufficient time to process data, it may be possible to do better than employing a heuristic that uses a mental shortcut. However, as uncertainty increases, the time to make a decision becomes constrained, and the quality declines of the information that supports analysis, a heuristic may perform better than a more complex, data-driven approach. The nature of this set of tradeoffs was formalized by Simon (1957) with the term "bounded rationality." Bounded rationality refers to the fact that the ability of a decision maker to take as much time as needed to make an optimal decision is constrained by the quantity and quality of information available and the time available to make the decision. The overall constraint is the human mind's cognitive limitations in the pursuit of an optimal rather than satisfying (best decision, given the circumstances) decision.

Before the 1950s, finance was considered a proto-science (Jovanovic, 2008), a discipline without a robust theoretical framework. As a proto-science, financial decision making was driven by experience, available data, and simple analytical procedures developed to organize and process data for the decision maker to consider. In situations where there is good quality data and a validated analytical process, basic statistics and business condition indicators can be used effectively to judge the condition of a firm or an investment candidate. An example is the DuPont Model developed by Alfred Sloan in the 1920s for analyzing an entity's profitability as a function of asset turnover and profit margin, as a means to direct management's attention to those areas in the firm that require better oversight and management.

In another example, if we consider a situation where a decision maker needs to select between 3 capital investments, where there is a high degree of uncertainty and there is no theory describing how data associated with the investments can be processed to rank the investments, shortcuts based on experience may be the best approach. A popular heuristic going back to the 1800s for making the capital investment decision is the payback criterion. The investor makes the investment based on how quickly the investment can be recovered by future cash flows. If the criterion is to invest only when the investment can be recovered in three years, then any investment with a payback period beyond three years is foregone. If there are multiple investment opportunities available to achieve a goal, then the investor should select the

investment that pays back the quickest, as long it meets the minimum payback period requirement. This heuristic has stood the test of time and is still used as one method to select capital investments. Another heuristic for deciding how to allocate $X to multiple approved independent investment opportunities is to use the 1/N heuristic. For example, if there are three investments, then the investor allocates one-third of available funding to each. This heuristic is employed frequently when individuals allocate their 401K retirement funds among various investment options.

Perhaps the most well-known heuristic is the Pareto principle, referred to as the 80/20 principle, or focus on the "vital few rather than the trivial many". The basis for the principle was Pareto's (1906) research pointing out that in Italy approximately 80% of the country's income was earned by 20% of its population. The terms "Pareto principle" and "vital few and trivial many" were popularized by Juran (1954) based on his work in the 1940s applying the findings of Pareto to many areas of management, including finance. For example, capital investment programs appear to obey this principle, with a small percentage of projects accounting for a major portion of problems such as cost overruns and schedule slippages. Thus, a manager should focus on the 20% of the projects accounting for 80% of the associated problems.

Recent research has identified a number of additional heuristics used in general and financial decision making, such as those listed in Table 1(Gigerenzer & Wolfgang, 2011).

TABLE 1
ADDITIONAL HEURISTICS

Heuristic	Description
Recognition	If one of two alternatives is recognized and the other is not, then infer that the recognized alternative has the higher value with respect to the criterion
Fluency	If both alternatives are recognized but one is recognized faster, then this alternative is assumed to have higher value based on the criterion
Take-the-First	Choose the first alternative that comes to mind
Take-the-Best	Compare existing models and choose the best to copy
Fast & Frugal Trees	These are basically checklists rather than complex statistical techniques

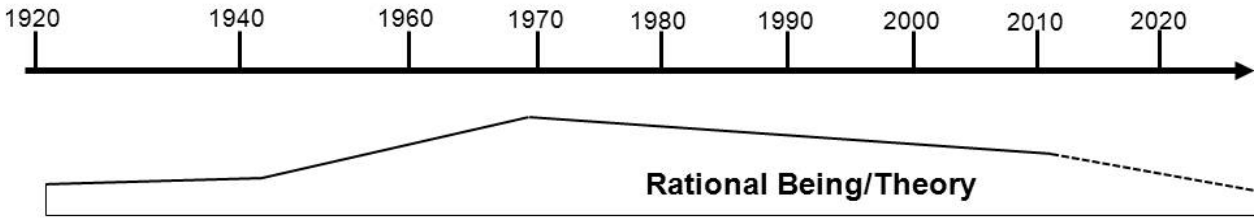
In sum, there are many heuristics (only a sampling has been discussed here) developed for different decision-making situations. In some cases, they are efficient and effective and have stood the test of time. In other instances, they have been relied upon due to poor judgments driven by emotions or mistakes in judging the nature of the tradeoff between urgency and uncertainty, and the availability of additional decision-making tools.

Heuristics are alive and well in both modern general management and financial decision making, as shown in some of the examples above. What we know about heuristics and how they are employed has changed markedly, primarily due to advances in knowledge about decision making behavior. The effective use of heuristics depends on a combination of factors: the experience of the decision maker, his or her awareness of the strengths and weaknesses of the heuristic, and the decision making context. For example, if time constraints are not an issue and there is sufficient time to gather additional information and apply decision making tools, then the justification for use of a heuristic is weak. Alternatively, if there is a high degree of uncertainty, a large amount of ambiguous information, and an urgency to make a decision, then informed use of a heuristic may be the best approach. A danger for modern decision makers is the availability of too much information, where the cognitive limitations associated with bounded rationality and a time constraint can lead to either "analysis paralysis" or improper reliance on quantitative analysis that is overly complex and insufficiently transparent. The use of heuristics and the timing of their use are closely related to the concept of intuition and the effects of emotions, which will be discussed in the neuroscience and unconscious sections of the paper.

RATIONAL BEING/THEORY PARADIGM

The period from the 1940s through the 1960s saw the development of most modern finance theory in the areas of asset, portfolio, and contingent claims pricing, along with capital structure and dividend policy theory. These theories together comprise a paradigm of financial decision making theory termed Rational Being, whose prominence peaked in about 1969, as indicated in Figure 3.

FIGURE 3
RATIONAL BEING/THEORY PARADIGM LIFE CYCLE



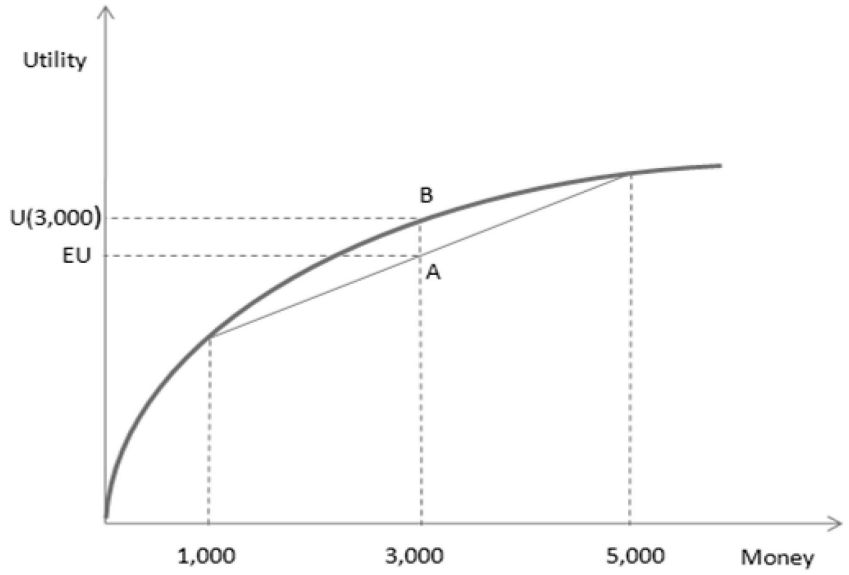
Development of this body of theory was based on the use of sophisticated techniques such as quadratic programming and concepts from classical economics. This was a significant departure from pre-1940s when observed behaviors in the market served as the basis of investment and trading principles.

This golden age of theoretical finance was ushered in with the theory of expected utility (Von Neumann & Morgenstern, 1944) with its assumptions of the rational decision maker, which included:

1. **Completeness**: People can ran- order all choices/alternatives (revealed preferences)
2. **Transitivity**: If alternative B is preferred to alternative A, and alternative C is preferred to alternative B, then alternative C is preferred to A.
3. **Continuity**: When an individual prefers A to B and B to C, then there should be a feasible combination of A and C in which the individual is then indifferent between this combination and alternative B.

Expected utility theory postulates that individuals act rationally and in accordance with these three assumptions laid out by Von Neumann and Morgenstern. Given these conditions, the expected utility curve reflecting how individuals make choices takes the form shown in Figure 4.

FIGURE 4
EXPECTED UTILITY THEORY



Note that the preferences for a (rational) risk-averse individual would be traced out as a concave curve and be represented by:
Risk-Averse Decision Maker: U(EP=3000) > U(P) or U(3000) > U (.50*1000 + .50*50000)

In other words, the utility of the expected prospect/gamble [U(EP=3000)] is greater than the utility of the gamble [U(P)]. The point on the curve where expected utility (EU) intersects the curve is the point where the individual is indifferent between that amount earned for certain and a gamble that pays either $1,000 or $5,000, each with a probability of .50. Note that this amount is less than the expected value of $3,000 because the individual is risk-averse.

This framework for individual decision making served as a basis for modern portfolio theory developed by Markowitz (1952, 1959), the theory of capital structure and dividends (Modigliani & Miller, 1958; 1963; Miller & Modigliani, 1961), The Efficient Markets Hypothesis (EMH; Fama, 1965), The Capital Asset Pricing Model (CAPM; Sharpe, 1964), the Black-Scholes Option Pricing Models (Black & Scholes, 1973), and numerous extensions of these efforts by other researchers.

The relationship between heuristics (plus analytical techniques such as the DuPont Model) and the rise of financial theory can be credited with the evolution of finance from a proto-science to a discipline with an underlying theoretical framework. It brought a structure to financial decision making that lessened the reliance on the use of heuristics. As a result, academics flocked to the new discipline, extending additions to theory and identifying applications. Heuristics still occupied an important role in real world decision making, especially with the work of Simon (1957) formalizing a decision making model with the concept of bounded rationality. One of the best-known instances of the persistence of certain heuristics is that of Harry Markowitz, the founder of modern portfolio theory, in his 1990 speech accepting the 1990 Nobel Prize in Economics. While his theory implies that all investors should determine the weight of assets by choosing a portfolio on the efficient frontier, he indicated that he simply used the 1/N rule, where N is the number of investment choices, to allocate his funds in his retirement account.

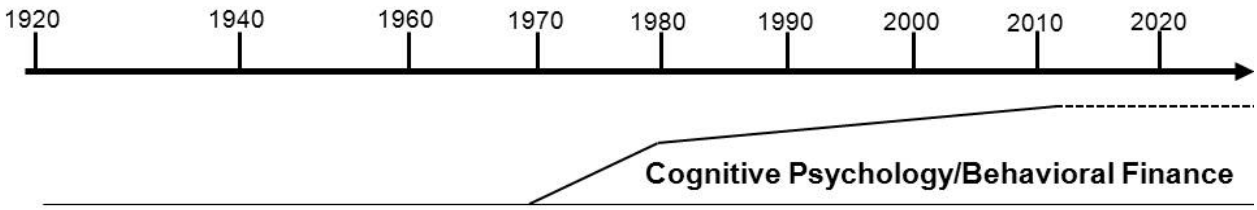
Financial theory was met by great enthusiasm and continued to build momentum through the 1960s; however, it did have its critics. Numerous exceptions to theory, especially to the EMH and the CAPM, were identified by researchers and practitioners. Given the strong assumptions required by the theories,

criticisms could be expected, but the volume and degree of deviations from how individuals were "supposed" to make financial decisions and how asset prices were "supposed" to act grew to a crescendo by 1970.

COGNITIVE PSYCHOLOGY/BEHAVIORAL FINANCE PARADIGM

The search was on for a new financial decision making paradigm as the failures of theory to adequately answer growing challenges to its validity continued to mount. The paradigm that began to emerge (Figure 5) drew on cognitive psychology.

FIGURE 5
COGNITIVE PSYCHOLOGY/BEHAVIORAL FINANCE PARADIGM LIFE CYCLE



An article appearing in a 1972 *Journal of Finance* paper (Slovic, 1972) began by quoting Smith (1968):

> *You are—face it—a bunch of emotions, prejudices, and twitches, and this is all very well as long as you know it. Successful speculators do not necessarily have a complete portrait of themselves, warts and all, in their own minds, but they do have the ability to stop abruptly when their own intuition and what is happening Out There are suddenly out of kilter……If you don't know who you are, this is an expensive place to find out.* (p. 779)

The main point made by Slovic is that the development of financial theory (describing how people should make financial decisions) made no provision for human emotions, which are important drivers in how people actually behave. His paper reinforced the challenges posed by the identified anomalies to the Rational Being theory described above. In cognitive psychology, experiments were being performed to explain some of the deviations from theory.

The incorporation of the findings of cognitive psychology into the body of financial knowledge has given rise to a branch of finance known as behavioral finance. Although the contributions to financial decision making by cognitive psychology responded to a number of the criticisms leveled at the normative behavior prescribed by financial theory, "behavioral finance" has also proven to be a contentious concept within the academic community. In general, critics concede that individuals can be irrational at times but maintain that, in the aggregate, such errors will cancel out and the market will be efficient due to arbitraging (otherwise known as "the law of one price"). Those academics and practitioners who favor behavioral finance maintain that there is a systematic deviation from theory in decision making behavior and argue that this can lead to violations to the Efficient Markets Hypothesis, as well as to serious errors at the level of the individual decision maker.

In experiments, researchers Daniel Kahneman and Amos Tversky (1972) observed how people behaved when offered various choices/gambles. They identified situations where people systematically behaved inconsistently with the rational models of economic/financial theory. This resonated with a number of academics and practitioners and stimulated the development of Prospect Theory (Tversky & Kahneman, 1973, 1974, 1981; Kahneman & Tversky, 1979; Kahneman, Slovic, & Tversky, 1982). These behavioral inconsistencies can be sorted into three categories: biases, heuristics, and framing effects.

Biases are the predispositions to commit specific types of errors, as summarized in Table 2.

TABLE 2
BIASES

Bias	Description
Excessive Optimism	When people overestimate how frequently they will experience favorable outcomes and underestimate how frequently they will experience unfavorable outcomes
Overconfidence	When people make mistakes more frequently than they believe and view themselves as better than average
Confirmation	When people attach too much importance to information that supports their views relative to information that runs counter to their view
Illusion of Control	When people overestimate the extent to which they can control outcomes
Hindsight	When subjects, after learning the eventual outcome, give a much higher estimate for the predictability of that outcome than subjects who predict the outcome without advance knowledge
Conservatism	Manifests as an attachment to past analyses, practices, beliefs, and commitments even when they start to prove erroneous, counterproductive, even unsustainable

As discussed earlier in this paper, the use of heuristics, when properly aligned to the situation, can be the best approach. However, when the decision context is misjudged based on the situation (uncertainty, limited availability of information, urgency) and on emotions, such simplifying shortcuts are subject to serious errors. Four heuristics categories are described in Table 3.

TABLE 3
HEURISTICS

Heuristic	Description
Representativeness	When people try to determine the probability that a data set A was generated by a model B, or that an object A belongs to class B, i.e., they evaluate the probability by the degree to which A reflects the essential characteristics of B
Availability	When people rely on information that is readily available and intuitive relative to information that is less salient and more abstract
Anchoring	When people form an estimate by beginning with an initial number and adjusting to reflect new information or circumstances; however, they tend to make insufficient adjustments relative to that number, thereby leading to anchoring bias
Affect	When people base their decisions primarily on intuition, instinct, and gut feeling

Typical of many of the behavioral findings from cognitive psychology, a decision making approach might have multiple characteristics that support classification in more than one scheme—say, as a bias by one researcher versus as a heuristic by another. Thus, no common classification scheme has been universally adopted in the literature. Researchers look at biases and heuristics with different perspectives and classify these financial decision making behaviors as biases or heuristics without common criteria. On the one hand, this lack of a standard has contributed to fragmentation and some confusion and has made the convergence to a common theory or paradigm less likely. However, this variability in classifications indicates that many of the observed behaviors may have a common source.

Framing effects in decision situations arise when different imagery and descriptions of the same problem highlight different aspects of the outcomes. Table 4 lists several examples.

TABLE 4
FRAMING EFFECTS

Framing Effect	Description
Glass Half Empty/Half Full	Preference for an option depends upon whether choices are couched in terms of probabilities of success or failure
Aversion to a Sure Loss	When subjected to a loss from a starting endowment, there is a tendency to hold the investment/project until break even, irrespective of whether the outlook is positive or negative for future performance
Mental Accounting	The mental account associated with the decision to accept a gamble includes money won or lost in that gamble and excludes other assets or the outcome of previous gambles

Research conducted to explain the formation and bursting of financial "bubbles" provides strong support for the position that humans are motivated to follow the herd in circumstances where emotions run high or where there are perceived risks/costs with deviating from the path being taken by most. Markets have been observed to reach extremes at times due to the herding behavior by sizable numbers of individuals. For example, the 1929 and 2000 stock market crashes after huge rises cannot be explained by the EMH. Parker & Prechter (2007) analyze a number of these bubbles and crashes and conclude that cycles of optimism and pessimism feed on each other, resulting in extreme levels of optimism and eventual reverses in asset prices. When the optimism has run its course and asset prices decline, it appears that virtually all investors reset their expectations, becoming pessimistic, and asset prices crash as extreme price declines are realized. Olsen (1996) observes a different form of herding in analysts' projections of future prospects for firms. They tend to follow the crowd as a means of protecting themselves from being wrong and from damages to their reputation (if they are wrong, then so was the majority).

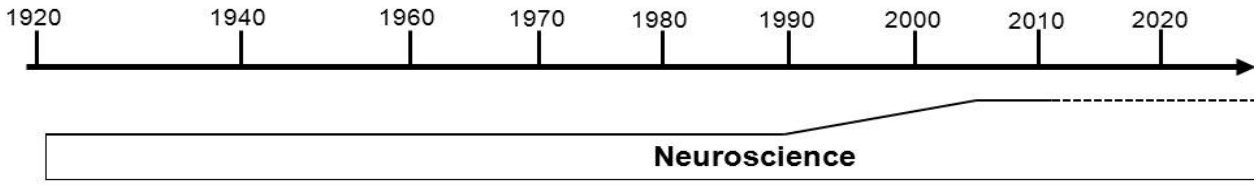
In standard finance theory, comparing alternative choices requires discounting expected future benefits back to the present at the required rate of return (or the return required to delay consumption to a future date) so that choices are made on a common basis (Samuelson, 1937). For example, savers may require a return on their money in a savings account of 3% annually as a requirement to save for future consumption and not spend in the present. A key finding from cognitive psychology is that humans deviate from the theory that dictates that the rate of time preference or discount rate is constant, by employing hyperbolic discounting in deciding whether to take rewards sooner rather than later. People tend to overweight the preference for immediate consumption. Frederick et al. (2002) cite a large number of studies implying that most people apply short termism or hyperbolic discounting in choices between taking a reward now or waiting for a larger reward. For example, in experiments, if people were offered $100 right now or $110 a week from now, which would they choose? Most subjects chose to take $100 now. It didn't seem worth it to wait for a week for only $10 more. On the other hand, if subjects were offered $100 a year from now or $110 a year and one week from now, most would wait the extra week and take the $110. These are equivalent choices in economic/finance theory, but people usually reverse their preferences and choose to wait an extra week for an extra $10 if the reward is delayed for a year. The further an event lies in the future, the less people care about it and the less it is affected by hyperbolic discounting. This propensity people have for short term rewards largely accounts for saving less and consuming more in the short term; it is one of the more serious problems faced in retirement planning. In corporate finance, such short termism accounts for overweighting self and corporate cash flow consumption in the near term and not making sufficient capital available for longer term investments. Unfortunately, incentives in executive compensation plans have tended to reinforce short termism or hyperbolic discounting instead of better aligning incentives and behavior with the welfare of shareholders, customers, and society in general.

As the graphic at the beginning of this section shows, the initial publications by Kahneman, Slovic, & Tversky attracted a great deal of interest and evolved into the related field of study termed behavioral finance. A diverse group of individuals from academia, psychology, corporate finance, investing, and financial advising have provided contributions to and have become stakeholders in the research and application of this new knowledge. This has been both positive and negative. The multiple perspectives have served an integrating function in helping to better understand complex human behavior. On the down side, the lack of a standard taxonomy in financial decision/behavioral errors has detracted from overall coherence. More importantly, there is no comprehensive theory or paradigm to explain and predict human decision making behaviors on a consistent basis; many "errors" have only been obvious in retrospect. In addition, new knowledge development in this field has followed the standard growth curve: initial strong advances, growth, and finally maturity and declining growth. The focus in the now mature stage of behavioral finance is in identifying new areas where this knowledge can be applied, such as executive compensation and incentive contracts, planning and investing for retirement, and the avoidance of serious mistakes in selecting corporate capital investments.

NEUROSCIENCE PARADIGM

Neuroscience has had a substantive impact on the study of financial decision making behavior since the mid-1980s, as shown in Figure 7.

FIGURE 7
NEUROSCIENCE PARADIGM LIFE CYCLE



Experimenters using various techniques from neuroscience are able to stimulate specific areas of the brain and then observe behavior in financial decision making tasks. Electrical signals are used in Transcranial Magnetic Stimulation (TMS) and Transcranial Direct Current Stimulation (tDCS) (Charron, Fuchs, & Oullier, 2008). Both TMS and tDCS have the ability to control the location and duration of the stimulus applied to the brain. These techniques use electrical current applied to a subject's cortex that disrupts the functioning of and communication between neurons. By correlating the location of the disruption to behavior, researchers form an assessment of that region's role in decision making.

Positron Emission Tomography (PET) using a radioactive tracer injected into the bloodstream has been in use since the 1950s to study brain function (Charron et al., 2008). Using PET, the researcher injects a radioactive tracer in the bloodstream of a subject prior to the beginning of an experiment, and the subject is placed into a cyclotron. The objective is to measure the concentration of this marker in the brain. When a brain area is active, more blood is required to carry oxygen to the area where the active cells are located. The injected tracer emits a positron that collides with its anti-particle, an electron, leading to a pair of photons of high energy that fly away in opposite directions and are detected by the PET scanner (Charron et al., 2008). An example of its use was by Zald et al. (2004) to study brain reactions for revenge in the trust game.

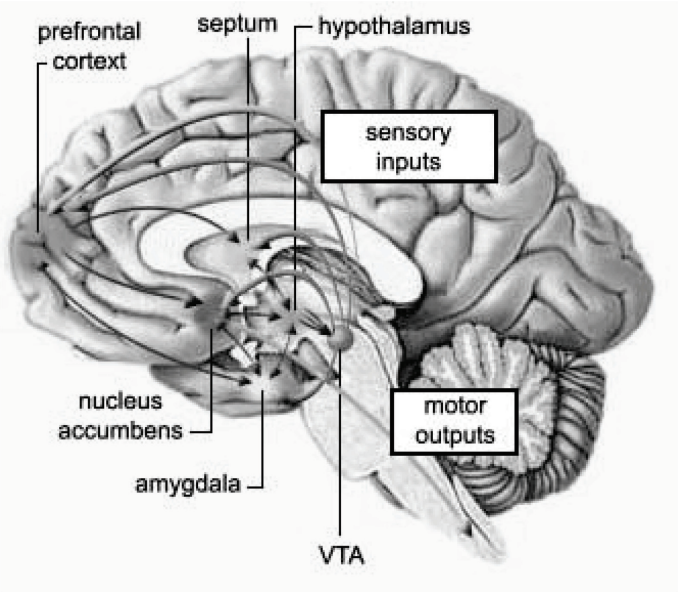
An important disadvantage of the TMS, tDCS, and PET approaches is that they are invasive, and therefore, they potentially corrupt observed behaviors related to financial decision making tasks in experimental situations. In addition, they do not show the detail in brain reactions that functional magnetic resonance imaging (fMRI) can. The fMRI is a noninvasive way to study in detail the brain's reactions to various situations within financial decision making experiments.

FIGURE 8
FUNCTIONAL MAGNETIC RESONANCE IMAGING

Source: Peterson (2004)

An fMRI scanner (Figure 8) applies a strong magnetic field to the subject and records the variations of the magnetic field caused by an increase in blood flowing to the brain. The change in this signal between an area that is active compared to the same area when it is not active is what the fMRI records in its brain images (Charron et al., 2008). It is important to note that these recorded changes in the brain are *indirect* indications of how the brain reacts to various financial decision making scenarios in experiments. The basic reactions are described in Figure 9 and below.

FIGURE 9
BRAIN LOSS-AVOIDANCE AND REWARD SYSTEMS



Source: http://thisisyourbrainon.wordpress.com/

In describing the following changes in the brain when exposed to various decision making situations and their emotional content, some liberty has been taken to simplify very complex processes that are still not well understood. Based on current knowledge, the human brain and its functions can be explained in terms of three major regions. The base of the brain, known as the *midbrain*, is the most ancient component and is located on top of the brain stem. It is part of the central nervous system and involved with hearing, motor control, vision, and body temperature regulation, and is estimated be around 250 million years old (equivalent to lizards and snakes). As life on Earth evolved, the *limbic system* developed. Located above the midbrain, it is the center of emotions and is estimated to be as old as 170 million years (equivalent to dogs). As a higher-level component of brain physiology, emotions are necessary to initiate action. The third part of the brain, what in its developed state makes us human, is the *prefrontal lobe/cortex* of the cerebrum lying around and on top of the limbic system. It is estimated to be about 40 million years old, though modern human behaviors, such as tool making, are not evident until around 80,000 years ago.

With fMRI, researchers can observe what happens in the brain as emotions signal that action is needed. The scanner uses radio waves and a strong magnetic field to make images of the brain that show brain activity. Neural activity causes changes in the need for oxygen, which causes changes in blood flow. Differences in the magnetic properties arising from hemoglobin in the blood when it is oxygenated, compared to when it is depleted of oxygen, result in magnetic fluctuations that are recorded by the fMRI.

As indicated earlier, as the center of human emotion, the limbic system initiates positive and negative emotions and communicates these to the prefrontal lobe of the cerebrum. In the limbic system, the *amygdala* is a key component of the loss avoidance circuit of the brain; it sets off the alarm for action in the face of threats and danger. In an emergency these strong impulses can generate an automatic response. For example, when faced with an imminent danger, the amygdala may impel the body to take actions without involving conscious thought. Early in human evolution, having an amygdala to quickly initiate action to avoid danger was necessary to survival. In humans' evolved state today, the amygdala still exerts strong forces on behavior. Experiments show that the amygdala is also stimulated when individuals make a risk-free choice (Peterson, 2007a).

The prefrontal lobe of the cerebrum is the executive manager that interprets impulses from the limbic system and makes conscious decisions on how to act. For example, when someone anticipates a loss or feels fear, the loss circuit in the limbic system lights up on the fMRI; when a gain (or pleasure) is anticipated, the reward (gain) circuit in the limbic system lights up (Bozarth, 1994). These emotions are communicated to the frontal lobes, where the emotions are interpreted, an evaluation process is conducted, and a decision is made.

The nucleus accumbens (NAcc) in the limbic system is the counter to the amygdala; it transmits excitement, anticipation, and pleasant sensations to the prefrontal lobe (Kuhnen & Knutson, 2005). Dopamine, a neurotransmitter, plays a key role in stimulating the NAcc by generating an intense feeling of excitement or anticipation; thereby facilitating motivations being turned into decisions and decisions into action. A study by Knutson, Adams, Fong, & Hommer (2001) found that NAcc activation represents gain prediction, while anterior amygdala/insula activation represents loss prediction (Paulus, Rogalsky, Simmons, Feinstein, & Stein, 2003). The nucleus accumbens also experiences increased blood flow when an individual is making a risky choice (Peterson, 2007a). Functional MRI experiments have shown how the NAcc reacts to dopamine in differing situations involving anticipated gains:

- Unanticipated gain – Strong reaction and feeling of pleasure in the gain circuit transmitted to the prefrontal cortex
- Gain equal to anticipated gain – Small or no reaction in the gain circuit
- Gain less than anticipated – Activity in the loss circuit of the limbic system, particularly the anterior insula

These findings provide some supporting explanation for evidence of momentum in stock prices and the forming and bursting of bubbles. During the forming of a bubble, the primary dynamic consists of a series of gains that exceed expectations, generating excitement and a continued rise in the asset price. As gains become more expected, the dopamine release is less in participants, and the activity in the gains

circuit declines, signifying the top of the bubble. The bubble bursts when dopamine no longer has an effect on the gain circuit/NAcc, and fear takes over as the loss circuit becomes active and a great mass of individuals seek to exit the asset at once.

The results indicate that anticipatory neural activation contributes to rational choice but may also promote irrational choice. Thus, financial decision making requires recruiting distinct anticipatory mechanisms for taking or avoiding risks, while remembering that excessive activation of one mechanism or the other may lead to mistakes. Overall, these findings suggest that risk-seeking choices (such as gambling at a casino) and risk-averse choices (such as buying insurance) may be driven by two distinct neural mechanisms involving the nucleus accumbens (NAcc) and the amygdala. Observed voluntary behaviors, such as financial decision making, are the result of the interactions of the limbic system (demanding action) with the frontal lobes of the cerebrum (evaluating and deciding). Observed outcomes in the form of financial decision making represent how the limbic system is working with the prefrontal lobes.

Neuroscience has helped to clarify and provide a physiological basis for the hypotheses and findings from cognitive psychology published for the past three decades. When the balance in a decision making context favors emotions, an individual is more prone to making mistakes. Biases, (bad) heuristics, and being subject to framing-effect errors are more likely in these circumstances. This finding is a major step forward in developing approaches for improving financial decision making. By educating individuals in the role of emotions and the importance of balancing the influences of the critical parts of the brain, it should be possible to get closer to realizing the goal of financial theory to use accumulated knowledge to improve financial decision making across the board. Jason Zweig (2007) spent a year with neuroscientists, participating in experiments and interpreting the information contained in many images from fMRI experiments. His conclusion is that people need first to know themselves, how naturally impulsive they are, what biases and heuristics they tend to employ, etc. As a result of his financial decision making experience in the field and time spent with neuroscientists, Zweig offers a series of suggestions to help build emotional intelligence and avoid bad decisions. Examples are to take a time out, step outside yourself, write yourself a policy, and so forth.

These Zweig "rules" are largely meant to help control the effect of emotions so that the different parts of the brain can work together in making the best decisions. Emotions are critical in alerting humans to situations that require action in the form of decisions, but the decisions should ideally reflect rational evaluation instead of relying too much on emotional content, which can lead to making serious mistakes. Zeelenberg, Nelissen, Breugelmans, & Pieters (2008) point out that there is no clear consensus among researchers on what emotions are. They propose that emotions are the initiators of action, similar to the affect heuristic of Slovic, Finucane, Peters, & MacGregor (2002), though they go beyond describing emotions as confined to positive or negative, pleasant or unpleasant (Solomon & Stone, 2002). For example, emotional states may be classified as regret, fear, excitement, pleasure, envy, angry, pride, love, shame, guilt, etc. Pfister and Böhm (2008) expand on the diversity of emotions by defining three functions, two of which relate directly to decision making:

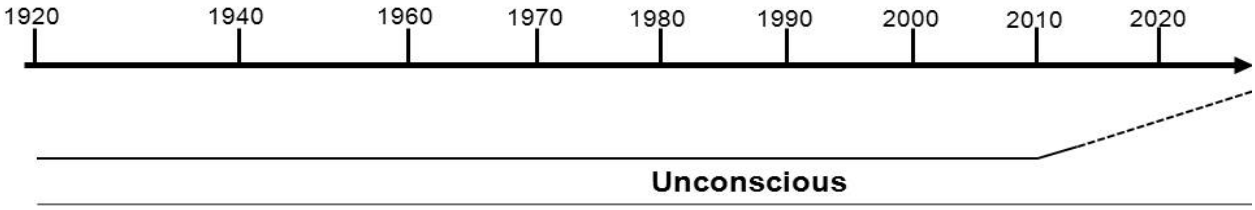
1. Speed - Emotions push people toward making timely decisions.
2. Relevance/Focus - Emotions help people focus on what is most important in the context of a decision making situation.
3. Commitment/Moral Sentiment - Emotions have physical effects on the human body that reflect trust, guilt, love, etc.

Learning more about emotions and their effects on financial decision making behavior is a major challenge for future research in neuroscience.

THE UNCONSCIOUS PARADIGM

The emerging Unconscious paradigm promises to be the dominant financial decision making paradigm of the near future (Figure 10).

FIGURE 10
THE UNCONSCIOUS PARADIGM LIFE CYCLE



An important recent paper by Mercier & Sperber (2011) argues that what researchers have labeled as biases and heuristics may be more accurately captured as a general unconscious "confirmation" bias. Overconfidence, excessive optimism, hindsight bias, availability, representativeness, etc., in this context all are considered to have an unconscious anthropological origin. Being outside the sphere of consciousness as the source accounts for their systematic occurrence, even when the subject is aware of the bias and reflects it in behavior anyway. The Mercier & Sperber theory has obvious tie-ins with neuroscience and cognitive psychology research, providing support for a more comprehensive approach to describing financial decision making. They rely on psychological research showing that people consistently fail in arguing logically (Evans, 2002), consistently exhibit biased reasoning (Kahneman, et al., 1982), and consistently make serious mistakes in estimating probabilities (Kahneman & Tversky, 1972; Tversky & Kahneman, 1983). Their conclusion is that there is something innate in humans at the unconscious level that serves as the source of this behavior. A general confirmation bias is portrayed as an evolutionary human adaption for communicating effectively in a group environment. This is consistent with anthropological conclusions about human brain development, that early humans were primarily motivated to develop survival strategies and that having a confirmation bias provided an effective framework for successfully communicating within their groups. Gaining access to resources and avoiding danger were high priorities for survival, and being able to agree to a baseline goal was critical to being a successful member of the group. As the human race evolved and basic survival became less of a concern, other goals became important. However, the reasoning supporting these goals (e.g.., objectivity, seeking the truth, persuading) is anchored by this internalized, unconscious confirmation bias.

Cheng (2010) describes unconscious thought as "… thought without attention, or with attention directed elsewhere" (p. 94). In the model he proposes, conscious thought is affected by a capacity constraint, whereas the unconscious has no such constraint. With no capacity constraint, improved judgment and decision making are possible through better organization of information in memory, implying that creativity is largely a product of the unconscious due to its greater capacity and the many unconscious "programs" at work in the mind. When very creative people are asked how they rationally achieved a great discovery, a typical response is that it just came to them without conscious thought. Cheng concludes his analysis by proposing a transcendent model for financial decision making where the total cognitive capacity of an individual consists of a conscious and an unconscious component. It is an interactive model where each component has its own coefficient signifying the relative importance of the conscious and unconscious in this interactive relationship. Given the differences between individual cognitive capacities, each person would have his or her own unique values to solve the model. Finding ways to test this model is one of the challenges for future researchers.

In *Incognito: The Secret Lives of the Brain*, Eagleman (2011) comments on the status of neuroscience and what it can currently tell us about the role of brain function in driving human behavior in response to expected losses and gains in decision making. As discussed earlier, fMRI brain imaging has been very helpful in showing how changes in the brain correlate to expected gain or loss before decisions are made; however, observations are indirect, and therefore, interpretations are not unambiguous. While the images for two subjects in similar experimental settings may be very similar, the behavior of the subjects may be quite different. Given any specific brain image, observed decision making behavior may occur along a

broad spectrum that ranges from one subject making a snap decision ruled by emotion and a reliance on heuristics, to another subject being stuck in an analysis-paralysis mode due to relying exclusively on the prefrontal lobes to come to a decision. This doesn't mean that brain imaging is useless, but it does demonstrate that behavior is mediated by a number of variables that cannot be sorted out by relying too heavily on the current status of fMRI imaging. In addition, recent research from brain imaging shows that the brain is very active before there is conscious awareness. As an extreme example, in an emergency situation the brain may react and stimulate danger avoidance action without *any* awareness, except after the fact. In addition to such automatic action, unconscious behavior can arise from internalized experience and knowledge that the individual is not consciously aware of (long term storage), repressed memories, internalized cultural behaviorisms, and inherited instincts, along with the unconscious "software" running the many programs controlling the body systems.

Increasing our understanding of the interactions of affect and/or emotion with intuition and the use of heuristics is critical to developing an improved and instructive financial decision making paradigm. Despite a good deal of research along these lines, there is still much we do not know about these relationships. There is also some ambiguity about the nature of both affect/emotion and intuition. For example, a branch of intuition research differentiates so-called "system 1" from "system 2" intuition (Kahneman, 2002). System 1 is composed of reactions that are heuristic, automatic/fast, associative, effortless, and difficult to control. System 2 processes are rational, cognitive, and more deliberately controlled. If we relate this taxonomy to neuroscience, system 2 is centered in the prefrontal cortex, the conscious, analytical, decision making part of the brain. System 1 lies outside our conscious awareness, in the unconscious.

An alternative description of intuition is the concept of fringe consciousness (Norman & Price, 2008). In this framework, intuition lies on a continuous spectrum from totally conscious to totally unconscious. In fringe consciousness, intuitive feelings provide an interface connection between the conscious and the unconscious. Norman (2010) also reviews the research attempting to define more clearly the domain of the conscious versus the unconscious. Her conclusion is that experiments demonstrate that there are gradations from unconsciousness to consciousness, which supports the idea of fringe consciousness. To clarify the true nature of intuition, we must learn much more about the unconscious; the path to this knowledge most likely will be revealed by further advances in neuroscience and cognitive psychology.

The conclusion from neuroscience and cognitive psychology research is that as much as 80-90% of our behavior has its origins in the unconscious (Eagleman, 2011). This represents the next frontier in gaining knowledge of how decision making behavior is formulated.

CONCLUSION

Advances in our understanding of financial decision making practices are evident when we examine the accumulation of knowledge over the past 100 years. We have gone through various phases of learning more about how people should and do make financial decisions. The transitions from one phase of knowledge development to another have not been seamless, nor has a single paradigm ever been totally dominant. Over 100 years ago, when simple analytics and heuristics dominated, there were small influences from theory, psychology, and brain science. Over time the then-current dominant paradigm has attracted criticisms for not being able to correct deficiencies in financial decision making behaviors. What was once a minor contributor, such as financial theory, then attracts attention as a new paradigm that appears to improve decision making knowledge systems. There may be "ah-ha" moments, such as elicited by the expected utility theory by Von Neuman and Morgenstern or the Prospect Theory by Kahneman & Tversky, that spark attention and attract researchers to a new emerging paradigm. Each distinct paradigm goes through the cycle of intense interest with a flurry of research, maturity and applications, and finally of decline when a new source of knowledge emerges. The new paradigm may derive from an "old" source simply biding its time as a minor contributor until there is a perceived major breakthrough. For example, the emerging paradigm, the unconscious, goes all the way back to Freud. Systematic exploration of the unconscious was not ready to make a major contribution to financial decision making theory until the

modern work in cognitive psychology and neuroscience laid the groundwork for stimulating new research.

Considering the breadth of accumulated knowledge and experience, one might conclude that financial decision making is now more science than art. Looking at the record of the recent past however, we see pervasively poor corporate financial decision making and individual investment retirement planning. In spite of what we have learned over the past century, we have become more aware than ever of what we do not know, or at least how to effectively apply what we do know. Research and experimentation in cognitive psychology and neuroscience over the past three decades point to unlocking the secrets of the unconscious as being the next important frontier in future advances in financial decision making knowledge. Decision makers should take this new field into account when making financial decisions. In addition, organizations should take the initiative to provide de-biasing training to its managers (financial and general management) as a means to improve the "emotional intelligence" of its members and reduce the risk of systematic errors in their decision making activities.

It is clear that this new paradigm will be highly multidisciplinary, where integration, synthesis, and the linking of emerging knowledge across many relevant fields will be required. Eagleman (2011) suggests that neuroscience will play a major role, as imaging and experimental tools become increasingly sophisticated and increasingly interdisciplinary approaches are employed to develop a more complete picture of human decision making. The medical field can also provide important contributions. Peterson (2007b) offers the possibilities of further medical experiments with brain chemicals (e.g., oxytocin, vasopressin, dopamine, and serotonin). The use of meditation, as implied by Cheng (2010), in a transcendental model, is an approach that deserves exploration. Finally, the fields of archeology, anthropology, sociology, and philosophy are demonstrating their potential to make important contributions to our knowledge of financial decision making and how to improve financial outcomes for individuals and organizations. Integration of these different perspectives is critical if we are to make significant advances in understanding and improving financial decision making.

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REFERENCES

Black, F., & Scholes, M. (1973). The pricing of options and corporate liabilities. *Journal of Political Economy*, 81 (3): 637–654. doi: 10.1086/260062.

Bozarth,M. (1994). Pleasure systems in the brain. In D.M.Warburton, ed., *Pleasure: The Politics and the Reality*. New York: John Wiley & Sons, 5–14. Retrieved January 5, 2012, from http://wings.buffalo.edu/aru/ARUreport01.htm.

Charron, S., Fuchs, A., & Oullier, O. (2008). Exploring brain activity in neuroeconomics. *Revue d'Économie Politique*, Jan/Feb: 97–124.

Cheng, Y. (2010). Improving financial decision making with unconscious thought: A transcendental model. *The Journal of Behavioral Finance*, 11 (2): 92–102. doi:10.1080/15427560.2010.482877.

Eagleman, D. (2011). *Incognito: The secret lives of the brain*. New York: Pantheon Books.

Evans, J. (2002). Logic and human reasoning: An assessment of the deduction paradigm. *Psychological Bulletin*, 128(6): 978–96. doi:10.1037//0033-2909.128.6.978.

Fama, Eugene (1965). The behavior of stock market prices. *Journal of Business*, 38: 34–105. doi:10.1086/294743.

Frederick, S., Loewenstein, G., & O'Donoghue, T. (2002). Time discounting and time preference: A critical review. *Journal of Economic Literature*, 40(2): 351–401. doi:10.1257/002205102320161311.

Gigerenzer, G., & Wolfgang G. (2011). Heuristic decision making. *The Annual Review of Psychology*. 62: 451–82. doi:10.1146/annurev-psych-120709-145346.

Juran, J. (1954). Universals in management planning and controlling. *The Management Review*, November.

Kahneman, D. (2002). Maps of bounded rationality: A perspective on intuitive judgment and choice. A Nobel prize lecture, December 8. Retrieved January 12, 2012, from http://nobelprize.org/nobel_prizes/economics/laureates/2002/kahneman-lecture.html.

Kahneman, D., & Tversky, A. (1972). Subjective probability: A judgment of representativeness. *Cognitive Psychology*, 3 (3): 430–454. doi:10.1037/h0031322.

Kahneman, D., & Tversky, A. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, 185 (4157): 1124–1131. doi:10.1126/science.185.4157.1124.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decisions under risk. *Econometrica*, 47 (2): 263–291. doi:10.2307/1914185.

Kahneman, D., Slovic, P., & Tversky, A. (1982). *Judgment under uncertainty: Heuristics and biases*. New York: Cambridge University Press. doi:10.1002/for.3980030211.

Knutson, B., Adams, C., Fong, G., & Hommer, D. (2001). Anticipation of monetary reward selectively recruits nucleus accumbens. *Journal of Neuroscience*, 21(16): RC159. doi:10.1523/JNEUROSCI.1564-07.2007.

Kuhnen, C., & Knutson, B. (2005). The neural basis of financial risk-taking. *Neuron*, 47: 763–770. doi:10.1016/j.neuron.2005.08.008.

Markowitz, H. (1952). Portfolio selection. *The Journal of Finance*, 7 (1): 77–91. doi:10.2307/2975974.

Markowitz, H.M. (1959). *Portfolio selection: Efficient diversification of investments*. New York: John Wiley & Sons.

Mercier, H., & Sperber, D. (2011). Why do humans reason? Arguments for an argumentative theory. *Behavioral and Brain Sciences*, 34 (2): 57–111. doi:10.1017/S0140525X10000968.

Miller, M. H., & Modigliani, F. (1961). Dividend policy, growth and the valuation of shares. *Journal of Business*, 34: 411-33. 10.1093/indlaw/dwi021.

Modigliani, F., & Miller, M. (1958). The cost of capital, corporate finance and the theory of investment. *American Economic Review*, 48 (3): 261–297.

Modigliani, F., & Miller, M. (1963). Corporate income taxes and the cost of capital: a correction. *American Economic Review*, 53 (3): 433–443. doi:10.2307/1809167.

Norman, E., & Price, M. (2008). Intuitive decisions on the fringes of consciousness: Are they conscious and does it matter? *Judgment and Decision Making*, (3)1: 28–41. Retrieved January 3, 2012 from http://journal.sjdm.org/bb3/bb3.html.

Norman, E. (2010). "The unconscious" in current psychology. *European Psychologist*, 15(3): 193-201. doi:10.1027/1016-9040/a000017.

Olsen, R. (1996). Implications of herding behavior for earnings estimation, risk assessment, and stock returns. *Financial Analysts Journal*, 52(4): 37–41. doi: 10.2469/faj.v52.n4.2009.

Pareto, V. (1906). *Manual of political economy*. (Italian; French translated, 1909, English translated, 1971). Publisher(s)?

Parker, W., & Prechter, R. (2007). The financial/economic dichotomy in social behavioral dynamics: The socionomic perspective. *Journal of Behavioral Finance*. 8(2): 84-108. Retrieved October 1, 2011, from SSRN: http://ssrn.com/abstract=1495051.

Paulus, M. Rogalsky, C., Simmons, A., Feinstein, J., & Stein, M. (2003). Increased activation in the right insula during risk-taking decision making is related to harm avoidance and neuroticism. *Neuroimage*, (19) 4: 1,439–1,448. doi:10.1016/S1053-8119(03)00251-9.

Peterson, R. (2004). Neuroscience and investing: fMRI of the brain's "reward system." Retrieved October 20, 2011, from http://www.richard.peterson.net/investinglessons.htm.

Peterson, R. (2007a). *Inside the investor's brain: The power of mind over money*. Hoboken, New Jersey: John Wiley & Sons.

Peterson, R. (2007b). Affect and financial decision-making: How neuroscience can inform market participants. *The Journal of Behavioral Finance*. 8 (2): 70–78. doi:10.1080/15427560701377448.

Pfister, H., & Böhm, G. (2008). The multiplicity of emotions: A framework of emotional functions in decision making. *Judgment and Decision Making*, 3(1): 5–17.

Samuelson, P. (1937). A note on measurement of utility. *Review of Economic Studies*, 4: 155–61. doi:10.2307/2967612.

Sharpe, W. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk. *Journal of Finance*, 19 (3): 425–442. doi:10.2307/2977928

Shefrin, H., & Statman, M. (1985). The disposition to sell winners too early and ride losers too long: Theory and evidence. *Journal of Finance*, 60(3): 777–790. doi:10.2307/2327802.

Shefrin, H. (2007). *Behavioral corporate finance*. New York: McGraw-Hill.

Simon, H. (1957). A behavioral model of rational choice. *Models of Man, Social and Rational: Mathematical Essays on Rational Human Behavior in a Social Setting*. New York: John Wiley & Sons.

Slovic, P. (1972). Psychological study of human judgment: implications for investment decision making. *Journal of Finance*, 27(4): 779-799. Retrieved September 15, 2011, from SSRN http://www.jstor.org/stable/2978668.

Slovic, P., Finucane, M., Peters, E., & MacGregor, D. (2002). The affect heuristic. In T. Gilovich & D. Griffin (Eds.), *Heuristics and biases: the psychology of intuitive judgment* (pp. 397–420). New York: Cambridge University Press.

Smith, A. (1968). *The money game*. New York: Random House.

Solomon, R., & Stone, L. (2002). On "positive" and "negative" emotions. *Journal for the Theory of Social Behavior*, 32 (4): 417–435. doi:10.1111/1468-5914.00196.

Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology,* 5 (2): 207–232. doi:10.1016/0010-0285(73)90033-9.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science,* 185 (4157): 1124–1131. doi:10.1126/science.185.4157.1124.

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science*, 211 (4481): 453–458. doi:10.1126/science.7455683

Tversky, A., & Kahneman, D. (1983) Extensional versus intuitive reasoning: The conjunction fallacy in probability judgment. *Psychological Review*, 90(4):293–315.

Von Neumann, J., & Morgenstern, O. (1944 second ed. 1947, third ed. 1953). *Theory of Games and Economic Behavior.* Princeton, NJ: Princeton University Press. doi:10.1214/aoms/1177730216.

Zald, D., Boileau, I., El-Dearedy, W., Gunn, M., Dichter, G., & Dagher, A. (2004). Dopamine transmission in the human striatum during monetary reward tasks. *The Journal of Neuroscience*, 24: 4,105-4,112. doi:10.1523/JNEUROSCI.4643-03.2004.

Zeelenberg, M., Nelissen, R., Breugelmans, R. & Pieters, R. (2007). On emotion specificity in decision making: Why feeling is for doing. *Judgment and Decision Making*, 3(1): 18–27. doi:10.1523/JNEUROSCI.4643-03.2004.

Zweig, J. (2007). *Your money and your brain: How the new science of neuroeconomics can help make you rich*. New York: Simon & Schuster. doi:10.1017/S1474747208003508.