SECTION I

Common Mistakes and Basic Biases

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Emotion, Neuroscience and Investing: Investors as Dopamine Addicts*

Understanding what happens in our brain when we make decisions may help us to learn to overcome some of the mistakes we make. Emotions are key. Our ability to exercise self-control over such impulses is limited and decreases with use! Too often we succumb to our hard-wired tendencies to focus on the short term and herd.

- Emotional decision-making is the default option for our brains. However, we all like to think that we only use logic to arrive at our decisions. In fact without emotion we would be largely incapable of making any decisions, but all too often we allow emotion to rule unchecked. Welcome to the human condition!
- Neuroscientists have recently uncovered two particular traits of significance to investors. The first is that we are hard-wired for the short term. We tend to find the chance of short-term gains very attractive. They appear to stimulate the emotional centres of the brain, and release dopamine. This makes us feel confident, stimulated, and generally good about ourselves.
- The second is that we appear to be hard-wired to herd. The pain of social exclusion (i.e. betting against everyone else) is felt in exactly the same parts of the brain that feel real physical pain. So pursuing contrarian strategies is a little bit like having your arm broken on a regular basis!
- Self-control over these impulses is very hard. Psychologists have found that self-control is a limited resource. The more we use it, the less we have left to deal with the next occasion when self-control is required.
- The good news is that we continue to make brain cells pretty much throughout our lives. And our brains aren't fixed forever, we can rearrange the neurons (a process called plasticity). We aren't doomed, we can learn, but it isn't easy!

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What goes on inside our heads when we make decisions? Understanding how our brains work is vital to understanding the decisions we take. Neuroeconomics is a very new field that combines psychology, economics and neuroscience. That may sound like the unholy trinity as far as many readers are concerned, but the insights that this field is generating are powerful indeed.

Before I head off into the realms of neuroscience I should recap some themes we have explored before that provide the backdrop for much of the discussion that follows. One of the most exciting developments in cognitive psychology over recent years has been the development of dual process theories of thought. All right, stay with me now, I know that sounds dreadful, but it isn't. It is really a way of saying that we tend to have two different ways of thinking embedded in our minds.

SPOCK OR McCOY?

For the Trekkies out there, these two systems can, perhaps, be characterized as Dr McCoy and Mr Spock. McCoy was irrepressibly human, forever allowing his emotions to rule the day. In contrast, Spock (half human, half Vulcan) was determined to suppress his emotions, letting logic drive his decisions.

McCoy's approach would seem to be founded in system X. System X is essentially the emotional part of the brain. It is automatic and effortless in the way that it processes information – that is to say, the X-system pre-screens information before we are consciously aware that it even made an impact on our minds. Hence, the X-system is effectively the default option. The X-system deals with information in an associative way, and its judgements tend to be based on similarity (of appearance) and closeness in time. Because of the way the X-system deals with information it can handle vast amounts of data simultaneously. To computer nerds it is a rapid parallel processing unit. In order for the X-system to believe that something is valid, it may simply need to wish that it were so.

System C is the "Vulcan" part of the brain. To use it requires deliberate effort. It is logical and deductive in the way in which it handles information. Because it is logical, it can only follow one step at a time, and hence in computing terms it is a slow serial processing unit. In order to convince the C-system that something is true, logical argument and empirical evidence will be required, and Table 1.1 provides a summary of the main differences between the two systems.

This dual system approach to the way the mind works has received support from very recent studies by neuroscientists who have begun to attach certain parts of the brain to certain functions. In order to do this, neuroscientists ask experiment participants to perform tasks while their brains are being monitored via electroencephalograms (EEG), positron emission topography (PET) or, most often of late, functional magnetic resonance imaging (fMRI). The outcomes are then compared to base cases and the differences between the scans highlight the areas of the brain that are being utilized.

Table 1.2 lays out some of the major neural correlates for the two systems of thinking that we have outlined in Table 1.1. There is one very important thing to note about these groupings: the X system components are much older in terms of human development. They evolved a long time before the C-system correlates.

THE PRIMACY OF EMOTION

This evolutionary age helps to explain why the X system is the default option for information processing. We needed emotions far before we needed logic. This is perhaps best explained

Table 1.1 Two systems of reasoning

System One/X-system/Reflexive/Intuitive	System Two/C-system/Reflective
Holistic	Analytic
Affective (what feels good)	Logical?
Associative – judgements based on similarity and temporal contiguity	Deductive
Rapid parallel processing	Slow, serial processing
Concrete images	Abstract images
Slower to change	Changes with speed of thought
Crudely differentiated – broad generalization	More highly differentiated
Crudely integrated – context-specific processing	More highly integrated – cross context processing
Experienced passively and preconsciously	Experienced actively and consciously
Automatic and effortless	Controlled and effortful
Self-evidently valid: "Experiencing is believing" or perhaps wishing is believing	Requires justification via logic and evidence

Source: Modified from Epstein (1991).

Table 1.2 Neural correlates of the two reasoning systems

X-system	C-system
Amygdala	Anterior cingulate cortex
Basal ganglia	Prefrontal cortex
Lateral temporal cortex	Medial temporal lobe

Source: DrKW Macro research.

by an example using fear, which is one of the better understood emotions.[1] Fear seems to be served by two neural pathways. One fast and dirty (LeDoux's low road), the other more reflective and logical (the high road), and the links to the two systems of thinking outlined above are hopefully obvious.

Imagine standing in front of a glass vessel that contains a snake. The snake rears up, the danger is perceived, and the sensory thalamus processes the information. From here two signals emerge. On the low road the signal is sent to the amygdala, part of the X system,[2] and the brain's centre for fear and risk. The amygdala reacts quickly, and forces you to jump back.

However, the second signal (taking the high road) sends the information to the sensory cortex, which, in a more conscious fashion, assesses the possible threat. This is the system that points out that there is a layer of glass between you and the snake. However, from a survival viewpoint, a false positive is a far better response than a false negative!

Emotions: Body or Brain?

Most people tend to think that emotions are the conscious response to events or actions. That is, something happens and your brain works out the emotional response – be it sadness, anger,

[1] Largely thanks to the work of Joseph LeDoux, see his wonderful book the *Emotional Brain* (1996) for details.
[2] Also know as the limbic system.

happiness, etc. Then your brain tells your body how to react – tear up, pump blood, increase the breathing rate, etc.

William James, the grandfather of modern psychology, was among the first to posit that actually true causality may well flow from the body to the brain. In James's view of the world, the brain assesses the situation so quickly that there simply isn't time for us to become consciously aware of how we should feel. Instead the brain surveys the body, takes the results (i.e. skin sweating, increased heart beat, etc.) then infers the emotion that matches the physical signals the body has generated.

If you want to try this yourself, try pulling the face that matches the emotion you wish to experience. For instance, try smiling (see, we aren't always miserable and bearish despite our reputations). If you sit with a smile on your face, concentrating on that smile, then very soon you are likely to start to feel the positive emotions that one associates with smiling.[3]

An entertaining example of the body's impact upon decisions is provided by Epley and Gilovich (2001). They asked people to evaluate headphones. While conducting the evaluation, participants were asked to either nod or shake their heads. Those who were asked to nod their heads during the evaluation gave much more favourable ratings than those who were asked to shake their heads.

In the words of Gilbert and Gill (2000), we are momentary realists. That is to say, we have a tendency to trust our initial emotional reaction and correct that initial view "only subsequently, occasionally and effortfully". For instance, when we stub a toe on a rock or bang our head on a beam (an easy thing to do in my house), we curse the inanimate object despite the fact it could not possibly have done anything to avoid our own mistake.

Emotions: Good, Bad or Both?

However, emotions may be needed in order to allow us to actually make decisions. There are a group of people who, through tragic accidents or radical surgery, have had the emotional areas of their minds damaged. These individuals did not become the walking optimizers known as *homo economicus*. Rather, in many cases, these individuals are now actually incapable of making decisions. They make endless plans but never get round to implementing any of them.[4]

Bechara *et al*. (1997) devised an experiment to show how the lack of emotion in such individuals can lead them to make suboptimal decisions. They played a gambling game with both controls (players without damage to the emotional centres of the brain) and patients (those with damage to the emotional parts of the brain). Each player was seated in front of four packs of cards (A, B, C and D). Players were given a loan of $2,000 and told that the object of the game was to avoid losing the loan, while trying to make as much extra money as possible. They were also told that turning cards from each of the packs would generate gains and occasional losses. The players were told of the impact of each card after each turn, but no running score was given.

Turning cards from packs A and B paid $100, while those from C and D paid only $50. Unpredictably, the turning of some cards carried a penalty. Consistently playing packs A and B led to an overall loss, while playing C and D led to an overall gain.

[3] For more on this see Paul Ekman's *Emotions Revealed* (2003). It is also worth noting that some developmental psychologists have designed programs to teach children to recognize the physical signs of emotions (such as anger) and then use thought to control those emotions. See Mark Greenberg's work on PATHS (www.prevention.psu.edu/projects/PATHScurriculum.htm). Much of the work has focused on teaching children to constrain their anger – a modern-day equivalent of counting to 10.

[4] For more on this see Damasio (1994).

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Table 1.3 Progress over the game

	Number of rounds		Percentage	
	Controls	Patients	Controls	Patients
Pre-punishment	0–10	0–10	100	100
Pre-hunch	10–50	9–80	100	100
Hunch	50–80	–	100	–
Conceptual	80+	80+	70	50

Source: Bechara *et al*. (1997).

Performance was assessed at various stages of the game. Four different periods were identified. The first involved no loss in either pack (pre-punishment); the second phase was when players reported they had no idea about the game, and no feeling about the packs; the third was found only in the controls, who started to say they had a hunch about packs A and B being riskier; and finally, the last phase, when (conceptual) players could articulate that A and B were riskier.

Table 1.3 shows the average number of rounds in each phase, and the percentage of players making it through each phase of the game. The patients were unable to form hunches, and far fewer survived the game.

Now cast your eye over Figures 1.1 and 1.2. Figure 1.1 shows the number of cards drawn from packs A and B (bad) and C and D (good) in each phase by the controls. In the pre-hunch phase they are already favouring the good packs marginally. In the hunch phase, controls are clearly favouring the good packs.

Now look at the performance of the patients in Figure 1.2. In the pre-hunch phase they continually chose the bad packs. As noted above, there was no hunch phase. And perhaps most bizarrely of all, even when they had articulated that packs A and B were a bad idea, they still picked more cards from those decks than from C and D! So despite “knowing” the correct

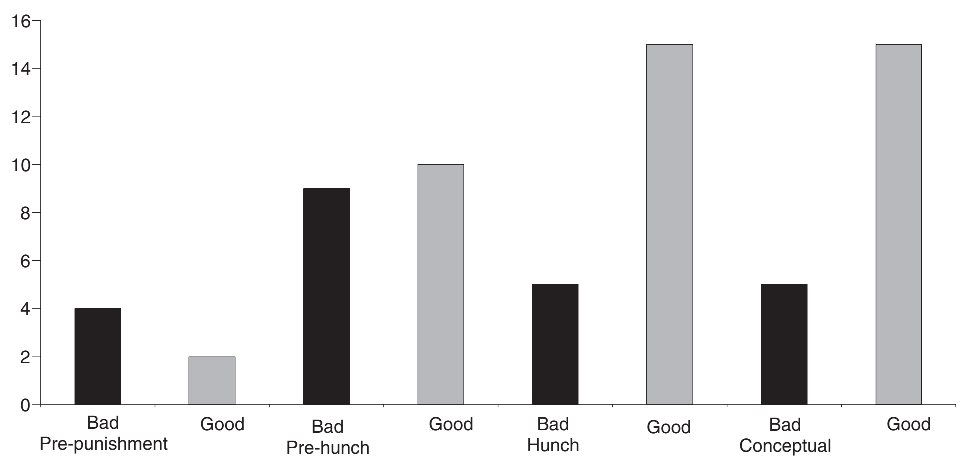

Figure 1.1 Average number of cards drawn from bad and good packs: The controls.
Source: Bechara *et al*. (1997).

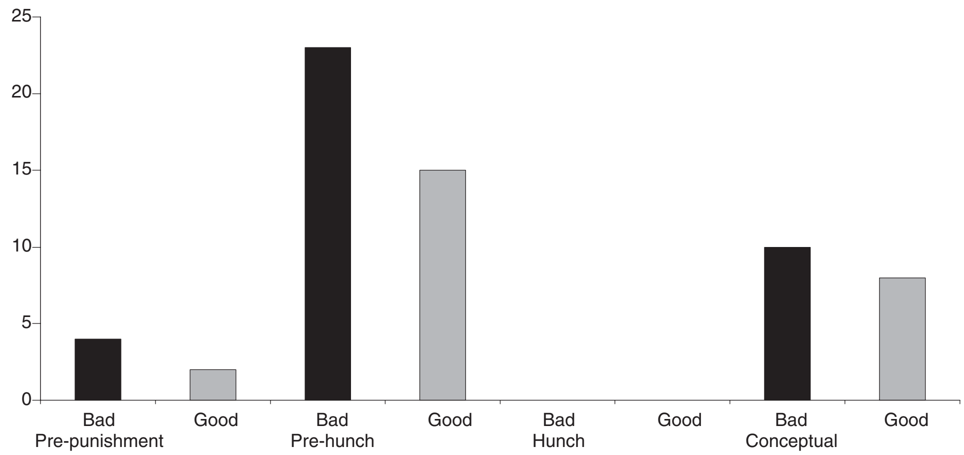

Figure 1.2 Average number of cards drawn from bad and good packs: The patients.
Source: Bechara *et al.* (1997).

conceptual answer, the lack of ability to feel emotion severely hampered the performance of these individuals.

However, similar games can be used to show that emotions can also help us. Bechara *et al.* (2004) played an investment game. Each player was given $20. They had to make a decision each round of the game: invest $1 or not invest. If the decision was not to invest, the task advanced to the next round. If the decision was to invest, players would hand over $1 to the experimenter. The experimenter would then toss a coin in full view of the player. If the outcome was a head, the player lost the dollar, if the coin landed tail up then $2.50 was added to the player's account. The task would then move to the next round. Overall 20 rounds were played.

Bechara *et al.* played this game with three different groups: normals, a group of players with damage to the neural circuitry associated with fear[5] (target patients who can no longer feel fear), and a group of players with other lesions to the brain unassociated with the neural fear circuitry (patient controls).

The experimenters uncovered that the players with damage to the fear circuitry invested in 83.7% of rounds, the normals invested in 62.7% of rounds, and the patient controls in 60.7% of rounds. Was this result attributable to the brain's handling of loss and fear? Figure 1.3 shows a breakdown of the results, based on the result in the previous round. It shows the proportions of groups that invested. It clearly demonstrates that normals and patient controls were more likely to shrink away from risk-taking, both when they had lost in the previous round and when they won!

Players with damaged fear circuitry invested in 85.2% of rounds following losses on previous rounds, while normal players invested in only 46.9% of rounds following such losses.

Bechara *et al.* also found evidence of just how difficult learning actually is. Instead of becoming more optimal as time moves on, normal players actually become less optimal! (See Figure 1.4.) For the record, a rational player would, of course, play in all rounds.

[5] Technically speaking this group had suffered lesions to the amygdala, orbitofrontal cortex and insular/somatosensory cortex – all parts of the X-system.

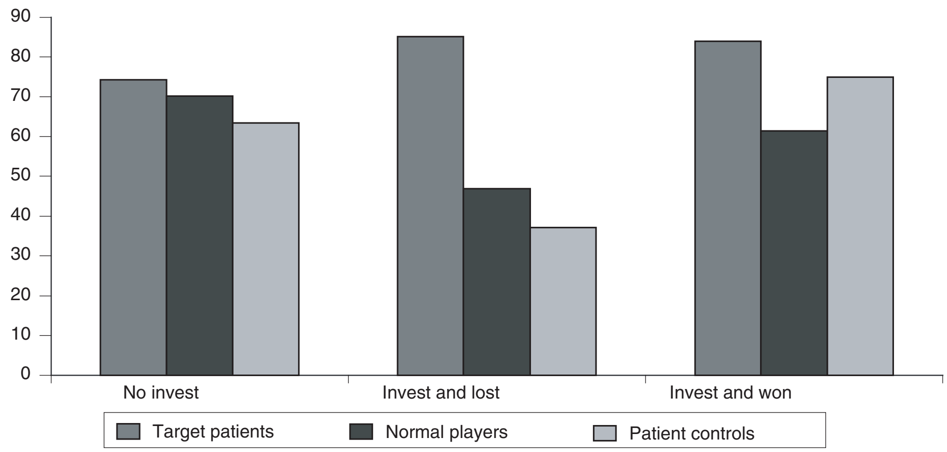

Figure 1.3 Percentage of players investing divided into the outcomes from the previous round.
Source: Bechara *et al*. (2004).

Emotion, therefore, can both help and hinder us. Without emotion we are unable to sense risk, but with emotion we can't control the fear that risk generates! Welcome again to the human condition!

Camerer *et al*. (2004) argue that the influence of emotions depends upon the intensity of the experience. They note

> At low level of intensity, affect appears to play a largely 'advisory' role. A number of theories posit that emotions carry information that people use as an input into the decisions they face. . .
>
> . . .At intermediate level of intensity, people begin to become conscious of conflicts between cognitive and affective inputs. It is at such intermediate levels of intensity that one observes . . . efforts at self-control. . .

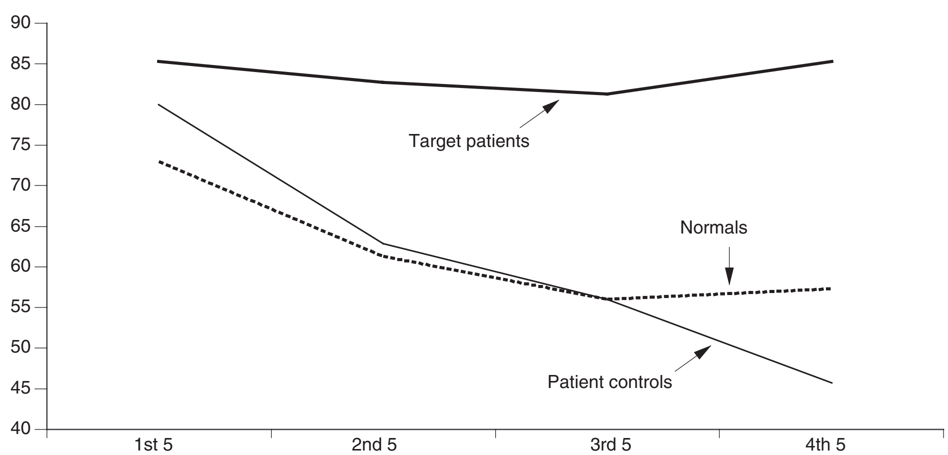

Figure 1.4 Percentage of players investing by groups of rounds.
Source: Bechara *et al*. (2004).

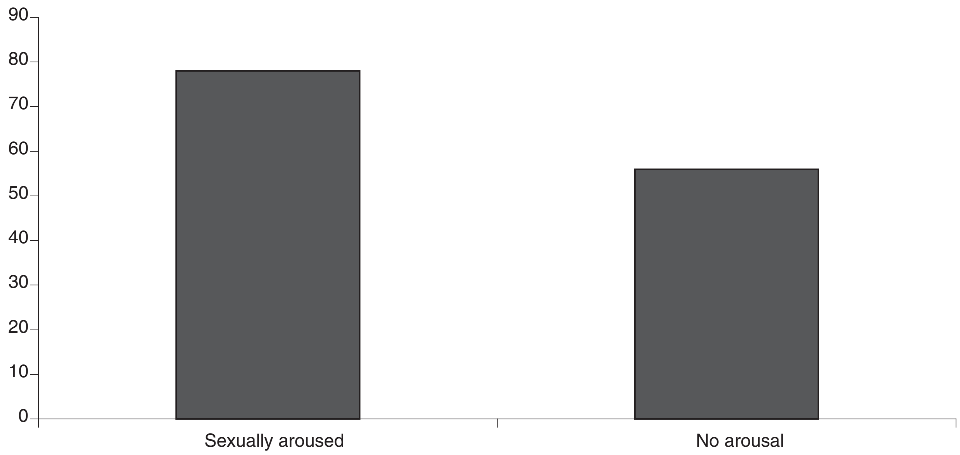

Figure 1.5 Probability of forceful behaviour by arousal state.
Source: Loewenstein *et al.* (1997).

> . . .Finally, at even greater levels of intensity, affect can be so powerful as to virtually preclude decision-making. No one 'decides' to fall asleep at the wheel, but many people do. Under the influence of intense affective motivation, people often report themselves as being 'out of control' . . . As Rita Carter writes in *Mapping the Mind*, 'where thought conflicts with emotion, the latter is designed by neural circuitry in our brains to win'.
>
> Camerer *et al.* (2004)

It is also worth noting that we are very bad at projecting how we will feel under the influence of emotion – a characteristic that psychologists call 'hot-cold empathy gaps'. That is to say, when we are relaxed and emotion free, we underestimate how we would act under the influence of emotion.

For instance, Loewenstein *et al.* (1997) asked a group of male students to say how likely they were to act in a sexually aggressive manner in both a hot and a cold environment. The scenario they were given concerned coming home with a girl they had picked up at a bar, having been told by friends that she had a reputation for being 'easy'. The story went on that the participants and the girl were beginning to get into physical genital contact on the sofa. The participants were then told they had started to try to remove the girl's clothes, and she said she wasn't interested in having sex.

Participants were then asked to assign probabilities to whether they would (1) coax the girl to remove her clothes, or (2) have sex with her even after her protests. Figure 1.5 shows the self-reported probability of sexual aggressiveness (defined as the sum of the probabilities of 1+2). Under the 'no arousal' condition there was an average 56% probability of sexual aggression. After having been shown sexually arousing photos, the average probability of aggression rose to nearly 80%!

SELF-CONTROL IS LIKE A MUSCLE

Unfortunately a vast array of psychological research (Muraven and Baumeister, 2000; Baumeister, 2003) suggests that our ability to use self-control to force our cognitive pro-

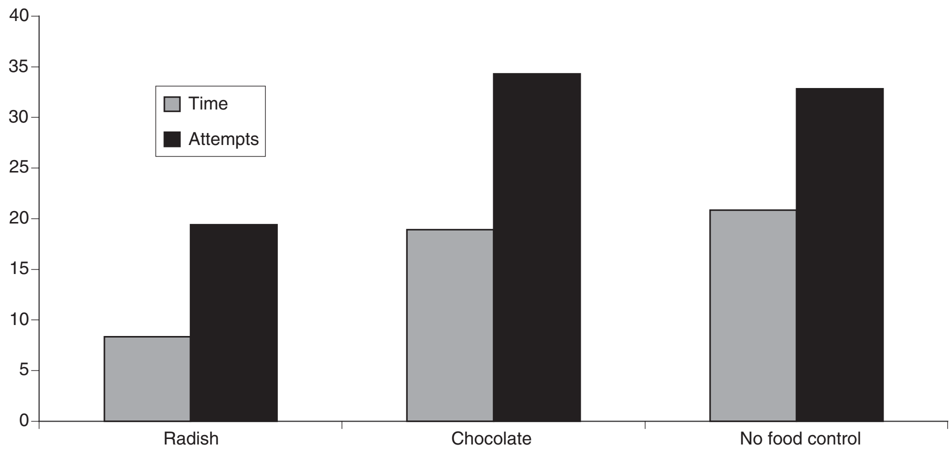

Figure 1.6 Self-control is a draining experience.
Source: Muraven and Baumeister (2000).

cess to override our emotional reaction is limited. Each effort at self-control reduces the amount available for subsequent self-control efforts.

A classic example of Baumeister's work concerns the following experiment. Participants are asked to avoid eating food for three hours before the experiment began (timed to force them to skip lunch). When they arrived they were put into one of three groups.

The first group were taken into a room in which cookies had recently been baked, so the aroma of freshly made chocolate chip delights wafted around. This room also contained a tray laid out with the freshly baked cookies and other chocolate delights, and a tray full of radishes. This group were told they should eat as many radishes as they could in the next five minutes, but they were also told they weren't allowed to touch the cookies. A second group was taken to a similar room with the same two trays, but told they could eat the cookies. The third group was taken to an empty room.

All the food was then removed and the individuals were given problems to solve. These problems took the form of tracing geometric shapes without retracing lines or lifting the pen from the paper. The problems were, sadly, unsolvable. However, the amount of time before participants gave up and the number of attempts made before they gave up were both recorded.

The results were dramatic (see Figure 1.6). Those who had eaten the radishes (and had therefore expended large amounts of self-control in resisting the cookies) gave up in less than half the time that those who had eaten chocolate or eaten nothing had done. They also had far less attempts at solving the problems before giving up.

Baumeister (2003) concludes the survey by highlighting the key findings of their research:

1. Under emotional distress, people shift toward favoring high-risk, high-payoff options, even if these are objectively poor choices. This appears based on a failure to think things through, caused by emotional distress.
2. When self-esteem is threatened, people become upset and lose their capacity to regulate themselves. In particular, people who hold a high opinion of themselves often get quite upset in response to a blow to pride, and the rush to prove something great about themselves overrides their normal rational way of dealing with life.

3. Self-regulation is required for many forms of self-interest behavior. When self-regulation fails, people may become self-defeating in various ways, such as taking immediate pleasures instead of delayed rewards. Self-regulation appears to depend on limited resources that operate like strength or energy, and so people can only regulate themselves to a limited extent.
4. Making choices and decisions depletes this same resource. Once the resource is depleted, such as after making a series of important decisions, the self becomes tired and depleted, and its subsequent decisions may well be costly or foolish.
5. The need to belong is a central feature of human motivation, and when this need is thwarted such as by interpersonal rejection, the human being somehow ceases to function properly. Irrational and self-defeating acts become more common in the wake of rejection.

When I read this list it struck me just how many of these factors could influence investors. Imagine a fund manager who has just had a noticeable period of underperformance. He is likely to feel under pressure to start to focus on high-risk, high-payoff options to make up the performance deficit. He is also likely to feel his self-esteem is under threat as outlined in 2 above. He is also likely to begin to become increasingly myopic, focusing more and more on the short term. All of this is likely to be particularly pronounced if the position run resulting in the underperformance is a contrarian one. Effectively, most of the elements that lead to the psychology of irrationality are likely to be present in large quantities.

HARD-WIRED FOR THE SHORT TERM

Having explored the role of emotions and our ability to moderate their influence, it is now time to turn to some examples of how powerful neuroscience can be in helping us to understand investor behaviour.

The first example suggests that we may be hard-wired to focus on the short term. Economists are all brought up to treasure the concept of utility[6] – the mental reward or pleasure experienced. Traditionally, economists view money as having no direct utility; rather it is held to have indirect utility, that is, it can be used to purchase other goods and services, which do provide direct utility.

Neuroscientists have found that money actually does have ‘utility’, or at least the brain anticipates receiving money in the same way that other rewards are felt, such as enjoying food or pleasure-inducing drugs (Knutson and Peterson, 2004).

The trouble is that the reward system for the brain has strong links to the X-system. The anticipation of reward leads to the release of dopamine. Dopamine makes people feel good about themselves, confident and stimulated.

Cocaine works by blocking the dopamine receptors in the brain, so the brain cannot absorb the dopamine, and hence nullify its effects. Because the brain cannot absorb the dopamine, it triggers further releases of the drug. So when one takes coke, the dopamine release is increased, taking the user to a high. Neuroscientists have found that the larger the anticipated reward the more dopamine is released.

McClure *et al*. (2004) have recently investigated the neural systems that underlie decisions about delayed gratification. Much research has suggested that people tend to behave impatiently today but plan to act patiently in the future. For instance, when offered a choice between £10 today and £11 tomorrow, many people choose the immediate option.

[6] In fact phychologists have recently argued that there is no single utility. Instead we have experienced utility (actual liking from an outcome), remembered utility (memory of liking), predicted utility (expected liking for the outcome in the future) and decision utility (the actual choice of outcome).

However, if asked today to choose between £10 in a year, and £11 in a year and a day, many people who went for the 'immediate' option in the first case now go for the second option.

In order to see what happens in the brain when faced with such choices, McClure *et al.* measured the brain activity of participants as they made a series of intertemporal choices between early and delayed monetary rewards (like the one above). Some of the choice pairs included an immediate option, others were choices between two delayed options. The results they uncovered are intriguing.

When the choice pair involved an immediate gain, the ventral stratum (part of the basal ganglia), the medial orbitofrontal cortex, and the medial prefrontal cortex were all disproportionately used. All these elements are associated with the X-system. McClure *et al.* also point out that these areas are riddled by the midbrain dopamine system. They note, 'These structures have consistently been implicated in impulsive behaviour, and drug addiction is commonly thought to involve disturbances of dopaminergic neurotransmission in these systems.' Since money is a reward, the offer of money today causes a surge in dopamine that people find very hard to resist.

When the choice involved two delayed rewards, the prefrontal and parietal cortex were engaged (correlates of the C-system). The more difficult the choice, the more these areas seemed to be used. Given the analysis of the limits to self-control that was outlined above, perhaps we should not hold out too much hope for our ability to correct the urges triggered by the X-system. All too often, it looks as if we are likely to end up being hard-wired for the short term.

Keynes was sadly right when he wrote, "Investment based on genuine long-term expectation is so difficult to-day as to be scarcely practicable."

HARD-WIRED TO HERD

In the past, we have mentioned that there is strong evidence from neuroscience to suggest that real pain and social pain are felt in exactly the same places in the brain. Eisenberger and Lieberman (2004) asked participants to play a computer game. Players think they are playing in a three-way game with two other players, throwing a ball back and forth.

In fact, the two other players are computer controlled. After a period of three-way play, the two other 'players' began to exclude the participant by throwing the ball back and forth between themselves. This social exclusion generates brain activity in the anterior cingulate cortex and the insula, both of which are also activated by real physical pain.

Contrarian strategies are the investment equivalent of seeking out social pain. In order to implement such a strategy you will buy the things that everyone else is selling, and sell the stocks that everyone else is buying. This is social pain. Eisenberger and Lieberman's results suggest that following such a strategy is really like having your arm broken on a regular basis – not fun!

> To buy when others are despondently selling and sell when others are greedily buying requires the greatest fortitude and pays the greatest reward
>
> Sir John Templeton

> It is the long-term investor, he who most promotes the public interest, who will in practice come in for the most criticism... For it is in the essence of his behaviour that he should be eccentric, unconventional and rash in the eyes of average opinion
>
> John Maynard Keynes

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PLASTICITY AS SALVATION

All of this may make for fairly depressing reading. With emotions we cannot control ourselves, and without them we cannot make decisions. We appear to be doomed to chase short-term rewards and run with the herd. When we try to resist these temptations we suffer subsequent declines in our ability to exercise self-control. Not a pretty picture.

However, all is not lost. For many years it was thought that the number of brain cells was fixed and that they decayed over time. The good news is that this isn't the case. We are capable of generating new brain cells over most of our lifetime.

In addition, the brain isn't fixed into a certain format. The easiest way of thinking about this is to imagine the brain as a cobweb. Some strands of that cobweb are thicker than others. The more the brain uses a certain pathway, the thicker the strand becomes. The thicker the strand, the more the brain will tend to use that path. So if we get into bad mental habits, they can become persistent.

However, we are also capable of rearranging those pathways (neurons). This is how the brain learns. It is properly called plasticity. We aren't doomed, we can learn, but it isn't easy!