**INVESTIGATING SOME NEUROMANAGERIAL MODELS**

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**Abstract**

*What happens in brain or is activated when Managers make decisions or are in the process of making decisions? Is study of decision-making via neuromanagement processes relevant for Managers? Many Managers seek information than required thereby causing delay because of time required to process information. This impairs effectiveness of decision. In this state, neuromanagement seeks to explain decision-making, ability to process multiple alternatives and choose optimal course of action. It studies how management behaviour shape understanding of brain and guide models of management. What are the coherent brain dynamics underlying prediction, control and decision making? Theoretical explanations posit that human brain accomplishes this through neural computations. Deciphering such transactions require understanding of neuro processes that implement value - dependent decision making. This leads to formulation of a ‘neuro - management decision making paradox’. The goal is a speculation of how brain implements decisions that is tied to behaviour. This Chapter attempts to explore phenomena through individual action, decision -making and reasoning processes. Objective is to put forward a model for neuro - management decision, in which interaction between variables of neuro - management decision processes are addressed through series of measurements of brain activity at time of decisions. Attempt is to describe a regular model for decision making process with intent of linking neuro - psycho and management levels of analysis capable of predicting observed behaviour.*

**Key Words:** Neuromanagement, Brain, Neuro - Management Decision Making Paradox

**Introduction**

 Decisions are inevitable part of individual activities with daily life being a sequence of decisions. Distinctively, researchers are interested in assumptions, beliefs, habits and tactics to make decisions. Any iteration of economics as a human endeavour would need some explanation of substrates, mechanisms and variable effects of emotional influence upon cognitive functions operative in decision-making processes relevant and relative to ecological resources. Brain considers sources of information before decision. Nonetheless, how does it do this? Why does process sometimes go awry, causing impulsive, indecisive and confused decisions that lead to potentially dangerous behaviours? Neuroeconomic decision making offers tools for modeling behaviour. With different disciplines approaching through characteristically different techniques and substantial advances, question of how we design and how we have to craft judgments / decisions has engaged researchers for decades. This research investigates neural bases of decision predictability and value, parameters in Economics of expected utility. Neuro - multiple - systems approach to decision - making, in turn, influences Economics, a perspective strongly rooted in organisational psychology and neuroscience. Integration of these offer exciting potential for construction of near - accurate models of decision - making.

It is an empirical fact that natural sciences have progressed when they have taken derived principles as point of departure, instead of trying to discover essence of things. Managerial economic decision making has its origins in two places; in events following neoclassical economic revolution of 30s and in birth of cognitive neuroscience during 90s. Over the initial decade of its existence, Managerial economic decision making has engendered strident debates of two kinds. First, researchers have argued over whether the synthetic field offers benefits. Second, researchers have argued over which form Managerial economic decision making ought to acquire. Question is how Managers (hereafter, Manager) make (economic) decisions.

What happens in brain or is activated when Managers make decisions or are in the process of making decisions? Is study of decision-making via neuromanagement processes relevant for Managers? Many Managers seek information than required thereby causing delay because of time required to process information. This impairs effectiveness of decision. In this state, neuromanagement seeks to explain decision-making, ability to process multiple alternatives and choose optimal course of action. It studies how management behaviour shape understanding of brain and guide models of management. What are the coherent brain dynamics underlying prediction, control and decision making? Theoretical explanations posit that human brain accomplishes this through neural computations. Deciphering such transactions require understanding of neuro processes that implement value - dependent decision making. This leads to formulation of a ‘*neuro - management decision making paradox’*. The goal is a speculation of how brain implements decisions that is tied to behaviour. This Chapter attempts to explore phenomena through individual action, decision -making and reasoning processes. Objective is to put forward a model for neuro - management decision, in which interaction between variables of neuro - management decision processes are addressed through series of measurements of brain activity at time of decisions. Attempt is to describe a regular model for decision making process with intent of linking neuro - psycho and management levels of analysis capable of predicting observed behaviour.

Origin of decision economics is traced to Smith’s publication of *The Wealth of Nations* in 1776. Smith described a number of phenomena, based on ad hoc rules that explained how features of environment influenced behaviour, critical for appreciating decision behaviour and aggregation of decisions. One School of thought was that regularities in behaviour could (*ceteris paribus*) provide psychological basis to manage economic fluctuations. This group began to investigate what (mathematical) structure of Managerial decisions might result from simple, primitive and assumptions on preferences with a strong normative flavour. Attention was focused on idealised Managerial decisions to describe how Managers choose. Weak Axiom of Revealed Preference was developed by Samuelson. Samuelson proved precisely that assumptions about binary Managerial decisions, revealing stable (weak) preferences, could have powerful inference. An extension, Generalized ‘Axiom of Revealed Preference posits that some Managerial decisions can be used to craft predictions about relative desirability of pairs of objects that have never been directly compared. What followed were series of additional theorems which extended scope of revealed - preference theory to Managerial decisions with uncertain outcomes whose likelihoods are known. Interesting is that they demonstrate a Manager who obeys ‘ as if ’ he has continuous utility function that relates subjective value of any gain to its objective value and ‘as if’ his actions were aimed at maximising total obtained utility. These form basis to anticipate analysis unique to decision economics. What followed was a period in which heterogeneous researchers began to develop models of mental processes and then correlate intermediate variables. This was also a landmark event to predict decisions from single neuron activity. Contributions characterised the idea that complex decision problems can be modelled through use of a simple rationality model (maximise utility function of decision Manager’s decision variables, a function which stanchly signify decision Manager’s preferences). Question is under what conditions such functions exist?

**Managerial Activity**: Managers make (economic) decision makings in complex situations. NeuroManagerial economic decision making needs a decision maker (Manager) responsible for economic decision making. This maker has number of alternatives and must choose the best alternative (or an optimised combination). When this has been made, events may have occurred (maker has no control). Each (combination) of alternatives, followed by an event, leads to a result with some quantifiable significance. Cognitive neuroscience research suggests that diverse preference orderings and decisions possibly will surface depending on which brain circuits are activated. This perchance contradicts the microeconomic postulate that one complete preference ordering provides sufficient information to predict decision and behaviour.

Sen argues that emergence of complete preference ordering may be prevented by existence of conflicting motivations. Sen criticises existence of competing motivations (or ‘reasons for decision’) stating that unique preference ordering is not sufficient for describing human behaviour (unless, by chance, all motivations provide the same preference ordering). Nonetheless, Sen does not provide an explanation of how different motivations impact on decision (explanation can be found in recent neuroscience research). One key insight is *modularity* of human brain (not all brain circuits get activated when executing response to given circumstances). Same stimuli may generate different behavioural responses depending on which brain circuits are activated. If hypothesis is accurate, different brain circuits can guide to different decisions depending on which brain structures and circuits are activated. Consequently, there would be various (possibly conflicting) preference orderings. Furthermore, if a particular brain circuit could act relatively insulated, distinctive preference ordering would result (closed system).

Consistency properties are internal to the neuroeconomic Managerial decision function that describes behaviour. Samuelson’s revealed preference formulation is scientifically more respectable (since) if an individual’s behaviour is consistent, then it must be possible to explain behaviour without reference to anything other than behaviour. Sen (2002) identifies ‘internal consistency’ approach and ‘self-interest pursuit’ approach, respectively. Internal consistency model explains behaviour by finding regularities in observed behaviour that enable to assess consistency without reference to anything other than (or external to) observed behaviour. In order to predict neuroeconomic Managerial decisions, researchers work out which preferences are consistent by checking whether agents’ do or do not violate certain axioms of revealed preference. Added approach is ‘self-interest pursuit’ approach. It is assumed that self-interest, represented by complete preference ordering, dominates all motivations in coherent matrix. ‘Rational’ behaviour will consist in pursuit of self-interest. This provides basis for application of utility theory in coherent analysis which represents chooser’s preferences and explains how preferences determine neuroeconomic Managerial decisions. Internal consistency is neither sufficient nor necessary condition of neuroeconomic Managerial decision. It is not sufficient because ‘[a] person who always chooses things he values least and hates most would have great consistency of behaviour, but he can scarcely count as a model of rationality. There may be actions that are rational but where axiomatic conditions of consistency of behaviour would not obtain. Internal (intrinsic) psychological structure of Manager may be affected by conflicting motivations, values or goals, each of them corresponding to a different ordering and interacting in a way that precludes emergence of internally consistent preference ordering. External (extrinsic) factors may influence neuroeconomic Managerial decision based on ‘menu-dependence’. Changes may modify attitude towards other elements thereby changing preference ordering. These contravene axiomatic conditions of internal consistency which require that orderings must be independent from external conditions.

Interpretation of Managerial activity in terms of neuroscience is typically concerned with the neurophysiological underpinnings of Managerial neurodecision Managerial economic behaviours. One key insight is *modularity* of human brain (not all brain circuits get activated when executing response to given circumstances). Same stimuli may generate different behavioural responses depending on which brain circuits are activated. If hypothesis is accurate, different brain circuits can guide to different decisions depending on which brain structures and circuits are activated. Consequently, there would be various (possibly conflicting) preference orderings. Furthermore, if a particular brain circuit could act relatively insulated, distinctive preference ordering would result (closed system).

Real-life decision making involves assessment, by cognitive and emotional processes, of incentive value of various actions available in particular situations. However, often situations require decisions between many complex and conflicting alternatives, with a high degree of uncertainty and ambiguity. The goal is to make better and 'rational' neuromanagerial economic decision making. Theories and prescriptions require a cognitive understanding Managerial Economic Behavioural Decisions Systems (MEBDS). The question of appropriate prescriptions is directed towards conceptualisation of Managerial economic behaviour equipped with implications for understanding strategy. Some Managerial economic behaviour fails to achieve goals of firm. One way of looking at is pre-existing framework of conceptualization and analysis can be resolved with the initial decision process. It also has to be recognized that once strategic decisions have been made and a suitable decision framework established, the Managerial work involved in such decisions takes on an increasingly routine aspect. Overall object will be to reach an acceptable balance so that decision is made in a timely manner and coordinated. Operational measure of balance / imbalance between neural systems is the extent of temporal discounting apparent in Manager’s neurodecision behaviour. This ensures that conflict between goals is minimised. Neuroeconomic explanation has often concentrated on functional and dysfunctional neurodecision Managerial economic behaviour.

**Somatic Markers**: In complex situations, cognitive processes may become overloaded and be unable to provide an informed option. In these cases (and others), Somatic Markers can aid decision process. In the environment, reinforcing stimuli induce an associated physiological affective state. These types of associations are stored as Somatic Markers, possibly in ventromedial prefrontal cortex (VMPFC; a subsection of orbitomedial PFC). In future situations, these Somatic-Marker associations are reinstated physiologically and bias cognitive processing. In cases where complex and uncertain decisions need to be made, Somatic Markers from all reward - and punishment-associated experiences with the relevant stimuli are summed to produce a net Somatic state. This overall state is used to direct (or bias) the selection of the appropriate action. This biasing process may occur covertly (unconsciously), via the brainstem and ventral striatum, or overtly (consciously), engaging higher cortical cognitive processing. Somatic Markers are proposed to direct attention away from the most disadvantageous options, simplifying the decision process. Before considering the MEBDS hypothesis, it is useful to note [Damasio’s (1994)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B37) Somatic Marker hypothesis which bases a model of decision-making systems on similar neurophysiological foundations but emphasizes the role of emotion and feelings, downplaying economic considerations. Decision-making reflects the Marker signals laid down in bioregulatory systems by conscious and non-conscious emotion and feeling; hence, Bechara and Damasio ([2005](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B12); see also [Bechara et al., 2000](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B13)) argue that in dealing with decision-making economic theory ignores emotion. Economics is exclusively concerned with ‘rational Bayesian maximization of expected utility, as if humans were equipped with unlimited knowledge, time, and information processing power’. They point, by contrast, to neural evidence which shows that ‘sound and rational’ decision-making requires antecedent accurate emotional processing ([Bechara and Damasio, 2005](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B12), p. 336; see also [Phelps and Sokol-Hessner, 2012](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B77)).

Damasio’s ([1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B37)) hypothesis is the outcome of brain lesion studies in which damage to the ventromedial prefrontal cortex (vmPFC) was found to be associated with behaving in ways that were personally harmful, especially insofar as they contributed to injury to the social and financial status of the individual and to their social relationships. Although many aspects of these patients’ intellectual functioning such as long-term memory were unimpaired, they were notably disadvantaged with respect to learning from experience and responding appropriately to emotional situations. Moreover, their general emotional level was described as ‘flat’. Damasio’s observation on these findings was that ‘the primary dysfunction of patients with vmPFC damage was an inability to use emotions in decision making, particularly decision making in the personal, financial and moral realms’ (Naqvi ; 2006). Thus was born the central assumption of the Somatic Marker hypothesis that ‘emotions play a role in guiding decisions, especially in situations in which the outcomes of one’s decisions, in terms of reward and punishment, are uncertain’ ([Bechara; 2011](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B11)). Of relevance here is the finding that the vmPFC may be implicated in activity of the parasympathetic nervous system (PNS), which in contrast to the sympathetic nervous system (SNS) is involved in the explorative monitoring of the environment and the discovery of novelty ([Eisenberger and Cole, 2012](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B113)). This is corroborative of both Damasio’s view and the nature and neurodecision Managerial economic behaviour of the innovative Manager discussed below.

Inherent in the Somatic Marker hypothesis is the attempt to describe not only the separate functions of the brain regions involved in emotional processing but also the interconnections between them ([Haber, 2009](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B58)). The starting point is operant neurodecision Managerial economic behaviour, particularly the mechanisms of reinforcement learning ([Daw, 2013](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B38); [Daw and Tobler, 2013](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B39)). Specific neurodecision Managerial economic behaviours eventuate in rewards as a result of which the amygdala triggers emotional/bodily states. These states are then associated via a learning process to the neurodecision Managerial economic behaviours that brought them about by means of mental representations. As each neurodecision Managerial economic behavioural alternative is subsequently deliberated upon in the course of decision-making, the Somatic state corresponding to it is re-enacted by the vmPFC. After being brought to mind in the course of decision-making the Somatic states are represented in the brain by sensory processes in two ways. First, emotional states are related to cortical activation (e.g., insular cortex) in the form of conscious ’gut feelings’ of desire or aversion that are mentally attributed to the neurodecision Managerial economic behavioural options as they are considered. Secondly, there is an unconscious mapping of the Somatic states at the subcortical level—e.g., in the mesolimbic dopaminergic system; in this case, individuals choose the more beneficial option without knowingly feeling the desire for it or the aversiveness of a less beneficial alternative ([Ross et al., 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B85); see also [Di Chiara, 2002](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B43); [Robbins and Everitt, 2002](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B80);[Tobler and Kobayashi, 2009](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B100)).

The rapidity with which the impulsive system acts in propelling neurodecision Managerial economic behaviour is underlined by [Rolls’s (2005)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B81) theory of emotion in which the reinforcing stimuli consequent on a neurodecision Managerial economic behavioural act as conditioned stimuli that elicit emotion feelings. The automaticity of this interaction of operant and Pavlovian conditioning may explanation for neurodecision Managerial economic behaviour in two ways. The emotion feeling may function as an internal discriminative stimulus to increase the probability of the neurodecision Managerial economic behaviour that produced it being reprised; it is equally likely that the emotion feeling is the ultimate reward of the neurodecision Managerial economic behaviour in question and that, by definition, it performs a reinforcing role ([Foxall, 2011](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B51)). Either way, the effects of basic emotions on subsequent responding is immediate and uninfluenced by reflection at the cognitive level. While the criticism of economics shown by the authors of the Somatic Marker hypothesis appears to rule an economic orientation out of their purview, the MEBDS approach actively builds on insights from operant neurodecision Managerial economic behavioural economics ([Bickel et al., 1999](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B27), [2010](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B22), [2011a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B20),[b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B24); Bickel and Vuchinich, 2000; [Bickel and Marsch, 2001](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B16); [Bickel and Johnson, 2003](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B15)).

While the Somatic Marker hypothesis relied in its inaugural stages on lesion studies, the central research technique of cognitive neuropsychology, the work of [Rolls (2005)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B81) offers confirmation of the role of operant neurodecision Managerial economic behaviour in the emerging paradigm. Recording single neurons’ activity levels, [Rolls (2005](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B81), [2008)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B82) reports that vmPFC neurons respond to the receipt of primary reinforcers such as pleasant-tasting foods. The integrity of the conditioning paradigm is evinced by the finding that devaluation of the reinforcer, for example through satiety, reduced the responses of such areas to these primary reinforcers. fMRI studies also offer corroboration.[Gottfried et al. (2003)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B55) report that when a predicted primary reinforcer is devalued then vmPFC activity engendered by that reinforcer is reduced. Hence, the vmPFC contributes to the prediction of the reward values of alternative neurodecision Managerial economic behaviours by reference to their capacity to generate rewarding consequences in prior occasions.[Schoenbaum et al. (2003)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B86) used lesion and physiological studies to show that this capacity to encode predictive reward value depends on an intact amygdala.

The MEBDS model differs in emphasis from Damasio’s Somatic Marker hypothesis. Their underlying similarity inheres in an acknowledgement that separate functions are performed within the overall impulsive-executive system. But Bickel draws attention to the interconnected operations of the impulsive system and the executive system in the production of neurodecision Managerial economic behaviour ([Bickel et al., 2007](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B25)). The MEBDS hypothesis is open, moreover, to the incorporation of economic analysis in the form of neurodecision Managerial economic behavioural economics and neuroeconomics ([Bickel et al., 2011a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B20)). Impulsive action, defined as the decision of a smaller but sooner reward (SSR) over a larger but later reward (LLR), is certainly associated with the over- activation of the older limbic and paralimbic areas, while the valuation and planning of future events and outcomes engages the relatively new (in evolutionary terms) PFC. However, it is the interaction of these areas, which are densely inter-meshed, that generates overt neurodecision Managerial economic behaviours. The MEBDS hypothesis thus stresses the continuity of the components of the neurophysiological-based decision system and Bickel’s conception is therefore one of a continuum on which the impulsive and executive systems are arrayed theoretically as polar opponents ([Porcelli and Delgado, 2009](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B79)).

Specifically, [Bickel et al. (2012a)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21) identify, in addition to trait impulsivity, four kinds of state impulsivity: neurodecision Managerial economic behavioural disinhibition, attentional deficit impulsivity, reflection impulsivity and impulsive decision. Trait impulsivity is associated with mesolimbic OFC and correlates with medial PFC, pregenual anterior cingulate cortex (ACC) and ventrolateral PFC; venturesomeness (sensation-seeking) correlates with right lateral orbitofrontal cortex, subgenual anterior cingualate cortex, and left caudate nucleus activations. The concept of trait impulsivity recognizes neurodecision Managerial economic behavioural regularities that are cross-situationally resilient. Within this broad construct, sensation-seeking or venturesomeness is widely known to be related to a need to reach an optimum stimulation level. [Bickel et al. (2012a)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21) associate it with sensitivity to reinforcement, the theory of which has been extensively developed by [Corr (2008b)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B35) and is discussed in greater detail below. Of the four state impulsivities discussed by [Bickel et al. (2012a)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21), neurodecision Managerial economic behavioural disinhibition is associated with deficiencies in the anterior cingulate and prefrontal cortices, attentional deficit impulsivity with impairments of caudate nuclei, ACC, and parietal cortical structures, and with strong activity in insular cortex; reflection impulsivity with impaired frontal lobe function; and impulsive decision with increased activation in limbic and paralimbic regions in the course of the selection of immediate rewards.

This latter is again strongly predicted by RST ([McNaughton and Corr, 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B114)). It is debatable whether the state impulsivities mentioned here are anything other than the neurodecision Managerial economic behavioural manifestations of trait impulsivity in particular contexts. The four state impulsivities that [Bickel et al. (2012a)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21) note are probably outcomes of a general tendency to act impulsively from which they are predictable. Neurodecision Managerial economic behavioural disinhibition is the inability to arrest a pattern of neurodecision Managerial economic behaviour once it has started; it is also evinced in acting prematurely with deleterious outcomes. Attentional deficit impulsivity is failure to concentrate, to persevere with salient stimuli. Again, the outcome is the adoption of risky neurodecision Managerial economic behavioural modes with poor consequences. Reflection impulsivity is failure to gather sufficient information before deciding and acting; inability to get an adequate measure of the situation leads to unrewarding neurodecision Managerial economic behaviours. Impulsive decision is a neurodecision Managerial economic behavioural preference for a SSR over a LLR for which the individual must wait. All of these state impulsivities are actually neurodecision Managerial economic behaviours, the outcomes of trait impulsivity. More relevant to the present discussion ispreference reversal in which a longer-term, more advantageous goal is preferred (e.g., verbally) at the outset only to decline dramatically in relative value as the delivery of the earlier less advantageous reward becomes imminent.

[Bickel et al. (2012a)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21) define EFs as ‘neurodecision Managerial economic behaviour that is self-directed toward altering future outcomes’ (p. 363; see also [Barkley, 2012](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B6)) and point out that EFs are consensually associated with activity in the PFC. PFC is generally recognized as implicated in the integration of motivational information and subsequent decision-making ([Wantanabe, 2009](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B115)), exerting a supervisory function that governs the regulation of neurodecision Managerial economic behaviour ([Bickel et al., 2012a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21)); hence, [Bickel et al. (2012a)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21) point out, its designation as a supervisory attentional system (SAS; [Shallice and Cooper, 2011](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B93)).

While some authors emphasize a single element of EFs such as the attentional control of neurodecision Managerial economic behaviour or working memory or inhibition, others stress groups of elements: planning, working memory, attentional shifting or valuing future events, emotional aspects of decision-making. Addiction can then be viewed as a breakdown in the operations of the EFs or as impaired response inhibition leading to the increased salience of addiction-orientated cues. [Bickel et al. (2012a)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21) concentrate on Attention, Neurodecision Managerial economic behavioural flexibility, Planning, Working memory, Emotional activation and self regulation (EASR) which they group into three major categories: (1) the cross-temporal organisation of neurodecision Managerial economic behaviour (CTOB) which is concerned with the awareness of the future consequences of current or contemplated neurodecision Managerial economic behaviour and therefore with planning for events that will occur later; (2) EASR which involves the processing of emotion-related information and ‘initiating and maintaining goal-related responding’; and (3) metacognition which includes social cognition and insight, empathy, and theory of mind (ToM).

The CTOB comprises attention (closely related to dorsolateral prefrontal cortex (DLPFC), neurodecision Managerial economic behavioural flexibility (frontal gyrus activity; lesioning of PFC is well-known to be associated with the diminution of neurodecision Managerial economic behavioural flexibility ([Damasio, 1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B37); [Bechara, 2011](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B11)), neurodecision Managerial economic behavioural inhibition (right inferior frontal cortex and insula are activated during neurodecision Managerial economic behavioural inhibition which is also associated with reduced activity in left DLPFC, the right frontal gyrus, right medial gyrus, left cingulate, left putamen, medial temporal, and inferior parietal cortex), planning (in which DLPFC the VMPFC, parietal cortex, and striatum are implicated), valuing future events(in the case of previewing and selecting immediate rewards: limbic and paralimbic regions; in the case of long-term decisions: prefrontal regions; see [McClure et al., 2004](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B71)); and working memory (DLPFC, VMPFC, dorsal cingulate, frontal poles, medial inferior parietal cortex, frontal gyrus, medial frontal gyrus, and precentral gyrus; [Bickel et al., 2012a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21), pp. 363–367).

EASR concerned with the management of emotional responses is implemented in Medial PFC, lateral PFC, ACC, OFC. Metacognitive processes (MP) involve recognition of one’s own motivation and that of others which is implemented in the case of insight or self-awareness by the insula and ACC, and in the case of social cognition by medial PFC, right superior temporal gyrus, left temporal parietal junction, left somatosensory cortex, right DLPFC; moreover, impaired social cognition follows lesions to VMPFC ([Damasio, 1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B37); [Bechara, 2005](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B10); [Bickel et al., 2012a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21), pp. 367–368).

RST ([Gray, 1982](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B56); [Corr, 2008b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B35); [Smillie, 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B96)) includes the excitatory (impulsivity) and inhibition (executive) components of the MEBDS model but also permits us to make extensions relating to the expected neurodecision Managerial economic behaviour patterns that follow from each and the way in which individual differences can be summed up in terms of an ascription of personality types.[1](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#note1) RST proposes that the basic neurodecision Managerial economic behavioural processes of approach and avoidance are differentially associated with reinforcement and punishment and that individuals show variations in their sensitivity to these stimuli.[2](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#note2)

Approach is neurodecision Managerial economic behaviour under the control of positively reinforcing or appetitive stimuli and is mediated by neurophysiological reward circuitry that the theory categorizes as a Neurodecision Managerial economic behavioural Approach System or BAS. The BAS consists in the basal ganglia, especially in the mesolimbic dopaminergic system that projects from the ventral tegmental area (VTA) to the ventral striatum (notably the nucleus accumbens) and mesocortical DA PFC ([Smillie, 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B96); cf. [Pickering and Smillie, 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B78)). For recent discussion of the role of the striatum in decision-making and the processing of rewards, see [Delgado and Tricomi (2011)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B41). Recent research demonstrating the role of this dopaminergic system in formulating ‘reward prediction errors’ is consonant with this understanding. Unpredicted reward is followed by increase in phasic dopaminergic activity whereas unpredicted non-reward is followed by a decrease and unchanged when reward is entirely predicted ([Schultz, 2000](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B87), [2002](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B88);[Schultz and Dickinson, 2000](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B89); [Schultz et al., 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B90)). Unpredicted reward instantiates the activity of the BAS, therefore, and predicted reward maintains its operation. Moreover, BAS activity increases positive reward (pleasure) and motivates approach to reinforcing stimuli and stimuli that predict reinforcement. Such approach is characteristic of the extraverted personality; [Corr (2008b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B35), p. 10) sums up the personality type as ‘optimism, reward-orientation and impulsivity’ and notes that it maps clinically on to addictive neurodecision Managerial economic behaviours.

These emotional and motivational outcomes represent one pole of a continuum of individual differences that manifest differential BAS and Neurodecision Managerial economic behavioural Inhibition System (BIS) reactions to stimuli. There is a corresponding though antithetical explanation of avoidance in RST. Avoidance is shaped by sensitivity to stimuli of punishment and threat and mediated by two bio-neurodecision Managerial economic behaviourally based systems of emotion and motivation. The first of these, the Fight-Flight-Freeze system (FFFS), is triggered by aversive stimuli and the resulting feeling of fear, what [Corr (2008b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B35), p. 10) refers to as the ‘get me out of here emotion’; the FFFS’s motivational output is a neurodecision Managerial economic behaviour pattern characterized as ‘defensive avoidance’. However, if the consequential stimuli involved are mixed in terms of their emotional valence then the BIS, which is involved generally in the resolution of goal-conflict is activated; in this case, the emotional output is anxiety, the ‘watch out for danger’ emotion [Corr (2008b, p. 11)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B35) and the neurodecision Managerial economic behavioural outputs are risk evaluation and cautiousness which are described as manifesting defensive approach. Hence, in summary, reward sensitivity leads to positive emotion and approach and a response pattern that is characterized as ‘extraversion’ via neurodecision Managerial economic behavioural observation or psychometric testing; by contrast, punishment sensitivity leads to negative emotion and avoidance and a personality characterized in terms of neuroticism ([Smillie, 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B96)).

RST also relates the FFFS and BIS to specific neurophysiological systems. In the case of the FFFS this is the periaquedital gray, which is implicated in acute or proximal threat, and the medial hypothalamus, amygdala and interia cingulate cortex, implicated in distal threats. The BIS comprises the septo-hippocampal system and the amygdala. The emotional output of the FFFS is fearfulness while that of the BIS is anxiety. In either case, the emotional outputs are negative and most forms of RST relate this to neuroticism. The value of employing explanatory constructs referring to personality types such as extraversion and neuroticism is that they summaries individual differences in reinforcement sensitivity, adding both to the interpretation of neurodecision Managerial economic behaviour and to its prediction in novel environments.

Dysfunctional neurodecision Managerial economic behaviours are those dominated by either the impulsive system or the executive system. The impulsive system evolved because it was evolutionarily-adaptive as far as inclusive fitness was concerned. Its preoccupation with short-term goals and its immediate response to opportunities ensured its contribution to survival of the individual and thereby to its biological fitness. It is closely related to the kinds of modular functioning posited by [Fodor (1983)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B46) which allows rapid responses to environmental concerns. It is closely related also to the emotion-feelings associated with such response capacity, pleasure in particular but also arousal and dominance. These are the ultimate rewards of instrumentally conditioned neurodecision Managerial economic behaviour ([Rolls, 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B82); [Foxall, 2011](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B51)).

When we speak of the dysfunctional consequences of a hyperactive impulsive system in seeking to understand and explain a Manager’s neurodecision Managerial economic behavioural repertoire we are referring to hyperactivity in these emotional-reward systems which leads, for instance, to preoccupation with short-term goals at the expense of undertaking longer-term planning, the reckless taking of investment decisions promising rapid high returns and a consequent over-cautiousness, and an unwillingness to invest in future. Another manifestation is rigidity in the pursuit of a previously selected goal even though the environment has changed and flexibility is called for. We are also suggesting that it is unlikely that this impulsive-hyperactivity occurs in isolation from hypoactivity of the executive system. Hence, imbalance occurs because Managers place disproportionate importance on the emotional highs resulting from activities that result in immediate or near-immediate reinforcement at the expense of the pursuit of considered action that would be under the control of the executive system. Moreover, both utilitarian reinforcement and informational reinforcement are engendered which brings about high levels of pleasure and arousal, and in a context that permits the emotion-feeling of high dominance ([Kringelbach, 2010](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B65);[Foxall, 2011](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full" \l "B51)). This is probably the strongest combinations of interacting reinforcement for the maintenance of Managerial neurodecision Managerial economic behaviour. From the organisation’s point of view, if this neurodecision Managerial economic behavioural style becomes characteristic of a function, department or even of the firm as a whole, the outcome will be an overconcentration on administrative and operational activities at the expense of a strategic perspective which embraces and anticipates the opportunities and threats of the changing market-competitive environment.

However, dysfunctional neurodecision Managerial economic behaviour may also result from hypoactivity of the impulsive system and hyperactivity of the executive system ([Mojzisch and Schultz-Hardt, 2007](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B74)). The intellectual rewards of a preoccupation with long-term planning, obtaining and analysing information, mulling over strategic possibilities, may lead to a lack of strategic implementation so that the short-term decisions necessary for the day-to-day operations of the firm are neglected, working capital is lacking, the firm cannot continue. The pleasures and arousal resulting from cognitive activity and the feeling of dominance that this provides can manifest in organisational sclerosis which over-values intellectual engagement with Marker structures, competition and, especially, the strategic scope of the organisation. From the organisation’s viewpoint, if this neurodecision Managerial economic behavioural style becomes widespread, there will be an imbalance in favour of strategic planning and decision-making at the expense of the day-to-day imperatives of the firm’s response to the tactical neurodecision Managerial economic behaviour of competitors and the vagaries of consumer decision. The executive system also evolved because it favoured biological fitness. Its operation is much like that of the central cognitive function posited by [Fodor (1983)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B46).

In view of the importance of avoiding a general tendency towards either kind of imbalance in the neurodecision Managerial economic behaviour of the firm, it might be argued that our unit of analysis should be the organisation as a whole since it is presumably structural elements in the organisation’s culture that require attention if the problem is to be overcome. This is undeniably correct but our present objective is less to overcome problems of imbalance, which are anyway the subject of innumerable management texts, and more to understand how individual Managers may be prone to one or other neurodecision Managerial economic behavioural style. The central factor involved in diagnosing either extreme at the individual level is the temporal horizon of the Manager since this correlates highly with the influence of the impulsive and/or executive systems. This is best considered, however, after the way in which cognitive language is used in neuro-neurodecision Managerial economic behavioural decision theory, which brings further understanding of the role of temporal horizon in decision-making. It also suggests a means of overcoming problems of impulsive-hyperactivity and executive-hypoactivity at the individual level which must be evaluated before an organisation-level solution can be proposed and appraised.

Neuroscience and neurodecision Managerial economic behavioural science employ extensional language, the third-personal mode which is taken as the hallmark of science ([Dennett, 1969](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B42)). The truth value of extensional sentences is preserved when co-designative terms are substituted for one another. The phrase, ‘the fourth from the sun’ can be substituted for ‘Mars’ in the sentence ‘That planet is Mars’ without surrendering the truth value of the sentence. However, the truth value of a sentence containing intentional language, such as ‘believes’, ‘desires’ or ‘feels’, is not maintained when co-designative are substituted. Given the sentence, ‘John believes that that planet is Mars’, we are not at liberty to say, ‘John believes that planet is the fourth from the sun’, since John may not know that Mars is the fourth planet. Intentional sentences have another unique property: the intentional inexistence of their subjects. The truth-value of my saying ‘I am driving to Edinburgh this weekend’, an extensionally-expressed statement, is established by there being a place called Edinburgh to which I can travel. But if I say that I am seeking the golden mountain, looking for the fountain of youth or yearning for absolute truth, none of the entities named in these intentional expressions need actually exist for the truth value of the sentences to be upheld. Finally, it is not possible to translate intentional sentences into extensional ones without altering their meaning. Intentional sentences usually take the form of an ‘attitude’ or verb such as believes, desires or wants followed by a proposition such as ‘that today is Tuesday’ or ‘that eggs are too expensive’; hence, such sentences are known as ‘propositional attitudes’ ([Chisholm, 1957](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B32)).

The proposed development of the MEBDS hypothesis involves more than terminological clarification. The principles just described govern not only linguistic usage but also the kinds of theories we invoke in order to explain our subject matter and care must be taken to ensure that each is confined to the level of explanation or interpretation to which it is appropriate. Cognitive terminology is intentional and belongs only at the level of the person ([Bennett and Hacker, 2003](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B14)).

[Dennett (1969)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B42) distinguishes the sub-personal level of explanation, that of ‘brains and neuronal functioning’ from the personal level of explanation, that of ‘Managers and minds’. The sub-personal level thus entails a separate kind of scientific purview and approach to explanation: by encompassing neuronal activity it is the domain of the neuroscientist and leads to an extensional explanation. The personal level which is the domain of mental phenomena is that of the psychologist; it requires an intentional explanation. A third level of explanation is required, however, in order to cover the whole range of phenomena and sciences that deal with them in a comprehensive approach to the explanation of neurodecision Managerial economic behaviour ([Foxall, 2004](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B47)). This is the super-personal level of explanation which encompasses operancy, the respect in which the rate of neurodecision Managerial economic behaviour is contingent upon its reinforcing and punishing consequences; this is the field of extensional neurodecision Managerial economic behavioural science.

Care is necessary to maintain the separation of these three levels since the mode of explanation which each entails is unique and cannot be combined with the others in a simple fashion. The fundamental difference in mode of explanation which must be constantly recognized is as follows. The sub- and super-personal levels, which are based on the neuro- and neurodecision Managerial economic behavioural-sciences respectively, require the use of extensional language and explanation. Both of which are in principle amenable to experimental (‘causal’) analysis, or failing this to the quasi-causal analysis made possible by statistical inference. They differ from one another in terms of the kind of stimuli and responses (independent and dependent variables) that must be taken into consideration in empirical testing of the hypotheses to which they give rise. They differ more fundamentally from the personal level of explanation, which attracts a wholly different mode of analysis, namely that of intentional psychology; the approach to explanation in this case relies on the ascription of beliefs, desires and feelings on the basis of non-causal criteria.

The proposed development of the MEBDS hypothesis involves more than terminological clarification. The principles just described govern not only linguistic usage but also the kinds of theories we invoke in order to explain our subject matter and care must be taken to ensure that each is confined to the level of explanation or interpretation to which it is appropriate. Cognitive terminology is intentional and belongs only at the level of the person ([Bennett and Hacker, 2003](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B14)).

The critique of the MEBDS hypothesis takes the form therefore of conceptual development. The MEBDS hypothesis is described by Bickel and colleagues in neuroscientific, cognitive and neurodecision Managerial economic behavioural terms without regard to the domains of explanation to which each of these categories belongs. For example, although they offer what purports to be a neurodecision Managerial economic behavioural definition of EF, they define several of its component parts in terms that are cognitive. Following [Barkley (1997a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B5),[b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B7)), they define EF as ‘as neurodecision Managerial economic behaviour that is self- directed toward altering future outcomes’ ([Bickel et al., 2012a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21), p. 363), but they list among those of its elements which suggest ‘CTOB’: attention, planning, valuing future events and working memory. These clearly are or involve cognitive events. Similarly, among the elements that make up ‘emotional and activation self-regulation’, they list: ‘the processing of emotional information’ and ‘initiating and maintaining goal-related responding’. Finally, as elements of ‘MP’ they list: ‘social cognition’ or ‘ToM’ and ‘insight’. [Bickel et al. (2012a)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21) define impulsivity neurodecision Managerial economic behaviourally in terms of actions prematurely performed that eventuate in disadvantageous outcomes. They go on, however, to describe impulsivity as consisting in the trait of impulsiveness, a structural personality variable that incorporates sensation-seeking, deficits in attention and reflection impulsivity which is an inability to collect and evaluate information prior to taking a decision. All of these are intensional.

So far we have advocated that neurodecision Managerial economic behavioural and neuroscientists maintain the appropriate syntax in speaking of intentional concepts such as beliefs and desires as opposed to extensional objects such as neurons and neurodecision Managerial economic behaviour patterns. This means understanding and maintaining the sub-personal, personal and super-personal levels of exposition and employing only the appropriate language at each level. A more satisfying outcome for neuro-neurodecision Managerial economic behavioural decision theory would be to incorporate a level of cognitive exposition the content of which complemented the extensional sciences we have discussed. This section sets out the criteria that such an explanation should fulfill; the following section evaluates picoeconomics ([Ainslie, 1992](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B1)) as that cognitive component.

There are four requirements of any candidate for the cognitive component of neuro-neurodecision Managerial economic behavioural decision theory. It must first be capable of filling the need for a personal level explanation of the causes of neurodecision Managerial economic behaviour. Second, it must provide an intentional explanation. Third, it should be capable of linking to the neurodecision Managerial economic behavioural economics and neuroeconomics analyses that are found in the hypothesis. And, finally, it must relate philosophically to broader disciplinary concerns including neurophysiology and operancy.

A cognitive explanation is required to provide understanding of the ways in which individuals subjectively respond to the circumstances which influence their neurodecision Managerial economic behaviour towards rewards that may have short-term benefits but which entail longer-term deleterious consequences. Being able to characterize what individuals desire and believe in these situations, what they perceive and how they feel, provides an indication of their underlying disposition to respond in a particular way to rewards and punishments occurring at different times. This is of course a highly theoretical enterprise; in order to avoid undue speculation and conjecture, therefore, it is important that the cognitive requirements of neuro-neurodecision Managerial economic behavioural decision theory are provided by a coherent body of knowledge relating personal level factors to situations that promote consumption.

The required personal level exposition must indicate the particular intentional terms that are applicable to the explanation of normal and addictive neurodecision Managerial economic behaviours within the framework of an overall theory that can systematically relate the two antipodal neurodecision Managerial economic behaviour patterns. It must also be capable of explaining how intentional entities like beliefs and desires, perceptions and emotions would act upon the impulsion towards fulfillment of immediate wants, such as consumption of an addictive substance, in order to bring about a more advantageous long-term result. This calls for a well-worked out theory of human neurodecision Managerial economic behaviour over the continuum of normal to addictive neurodecision Managerial economic behaviours rather than an ad hoc application of intentional language on the basis of rapid observation of an individual’s neurodecision Managerial economic behaviour.

The MEBDS hypothesis relies heavily on operant neurodecision Managerial economic behavioural economics and neuroeconomics in order to explain the reinforcer pathologies that underlie addictive patterns of neurodecision Managerial economic behaviour. It would be advantageous, therefore, for the cognitive component of the model to link to the basic exposition in economic terms. The usefulness of the cognitive explanation might be questioned because of its inherently theoretical nature; this objection can be overcome if its explanation of neurodecision Managerial economic behaviour can be specified in language that is consonant with the provisions of consumption in the face of extremely high elasticity of demand and temporal discounting of the consequences of neurodecision Managerial economic behaviour.

A broader relationship between the cognitive explanation of neurodecision Managerial economic behaviour and the underlying neuroscience and neurodecision Managerial economic behavioural science that comprise the MEBDS hypothesis is necessary that goes beyond economic integration. Although a major point of the present argument is that cognitive explanations differ fundamentally from those provided by the extensional sciences, the intentional component must be consistent with what is known of the neurophysiological basis of addiction and also with its relationship to the reinforcers and punishers that follow neurodecision Managerial economic behaviour.

[Herrnstein’s (1997)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B59) matching law suggests that the value of a reinforcer is inversely proportional to its delay, i.e., as the delay becomes shorter, the value increases dramatically. This is the essence of hyperbolic discounting. The key difference between exponential and hyperbolic discounting is that in the former the LLR is always preferable to the SSR, regardless of time elapsed, whereas in the latter there is a period during which the SSR is so highly valued (because the time remaining to its possible realization is so short) that it is preferred to the LLR ([Ainslie, 1992](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B1); [Ainslie and Monterosso; 2003](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B2)). This is clearly not because of its objective value which is by definition less than that which can be obtained through patience, but because the time remaining to its possible realization is now so short, that it is preferred to the later but larger reward. Ainslie notes that these findings harmonize with Freud’s observations that an infant behaves as if expecting immediate gratification but becomes, with experience, willing to wait for the longer-term alternative. In other words, still paraphrasing Freud, if the pleasure principle is resisted, the outcome will be the exercise of the reality principle. In the terminology of neurodecision Managerial economic behavioural psychology, the operant relevant to each of these principles are shaped by their respective outcomes. Ainslie argues that the two principles can be represented as two interests, each of which seems to employ devices that undermine the other.

In discussing what these devices are, [Ainslie (1992)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B1) gives a clue as to how we may speak of the operations of mental mechanisms and also how they are organised to produce phenomena in a cognitive explanation, i.e., one that conforms to the use of cognitive logic as we have defined it and to the strictures of grounded modularity as they were developed above. His first device, for instance, is precommitment, in which for instance one joins a slimming club in order to be able to call upon social pressures in order to reach long term goals. The very language of this explanation indicates the relevance of the models of cognition we have developed. The processes are unobservable, adopted in order to make neurodecision Managerial economic behaviour intelligible once the extensional explanations of neurodecision Managerial economic behavioural and neuro-science have been exhausted. Secondly, the interests may hide information from one another, e.g., about the imminence of rewards. Thirdly, the emotions that control short-term responding may be incapable of suppression once they are in train or they may be foreshortened by long-term interests. Finally, current decisions may be used as predictors of the whole pattern of neurodecision Managerial economic behaviour, consisting in a sequence of multiple neurodecision Managerial economic behaviours belonging to the same operant class that the individual will engage in future. An individual may, that is, see her present decision of a chocolate éclair as indicative that she will make this selection repeatedly and often in the future. Individual decisions are thus perceived as precedents. The resulting strategy is what Ainslie later described as bundling, in which the outcomes of a series of future events are seen cumulatively as giving rise to a single value. When this value, rather than that of a single future event, is brought into collision with the value of the single immediate decision, the long-term interest is thereby strengthened ([Baumeister and Vohs; 2003](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B8)).

Subsequent neurodecision Managerial economic behaviour that serves the longer rather than the shorter term interest is apparently rule governed rather than contingency shaped ([Skinner, 1969](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B116)). However, the ‘rules’ exist only in the mind of the individual who may not have encountered the contingencies. It is intellectually dishonest to refer to them as rules in the sense proffered by radical neurodecision Managerial economic behaviourists which require empirical confirmation that the individual has previously encountered similar contingencies or whose rule following neurodecision Managerial economic behaviour from others of similar kind to the present has been reinforced. Since we have no empirical, in particular, experimental indication of this nature, we would more accurately refer to them as beliefs. Our use of intentional language indicates the nature of our explanation or, better perhaps, interpretation. Ainslie himself refers to bundling as the basis of ‘personal rules’ but we can have no this- personal evidence of even the existence of such, let alone their efficacy. Better to characterize our explanation as interpretation and make this explicit by using intentional language.

Ainslie’s picoeconomics portrays the conflict between a smaller reward that is available sooner and a larger reward available later in terms of clashing intrapersonal interests. These are personal level events because their purpose is to render intelligible the neurodecision Managerial economic behaviour of an individual when it is no longer obvious how the contingencies of reinforcement/punishment and his neurophysiology are affecting his neurodecision Managerial economic behaviour. The neurodecision Managerial economic behaviour we are attempting to understand is often a single instance of activity (we are taking a molecular perspective) but the neurodecision Managerial economic behaviour which we employ to generate and justify the intentional interpretation we have to make is a pattern of neurodecision Managerial economic behaviour: here we are taking a molar standpoint. There must also be a pattern of neurophysiological activity which supports the strategic assumptions we are making about the individual. In addition, the pattern of reinforcement ([Foxall, 2013](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B52)) is of crucial importance in interpreting his neurodecision Managerial economic behaviour. We are ascribing interests and their effects in determining neurodecision Managerial economic behaviour but we employ constructs in order to accomplish this that are unobservable posits: they cannot enter into an experimental analysis. We use the molar neurodecision Managerial economic behaviour pattern, the pattern of reinforcement and neurophysiology to underpin these strategic assumptions and to justify our interpretation. The language of picoeconomics consists therefore in strategic assumptions that derive from an interpretation of the neurodecision Managerial economic behaviour and neurophysiology of the individual. The strategic assumptions we make and the way we use them must be consistent with the evolution of the species by natural selection, the ontogenetic development of the individual’s neurodecision Managerial economic behaviour through operancy, and the evolutionary psychology of the prevalent neurodecision Managerial economic behaviour of the species. We need to show how the neurodecision Managerial economic behavioural sensitivity to patterns of reinforcement (which are the subject of our studies of operancy and evolutionary psychology) are in turn related to evolution by natural selection via synaptic plasticity.

Picoeconomics explanations for neurodecision Managerial economic behaviour using intentional language, specifically the cognitive language of decision-making and problem-solving. In particular, as a theory of ‘the strategic interaction of successive motivational states within the person’ ([Ainslie, 1992](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B1)), it is dynamically concerned with the internal weighing of information about the outcomes of alternative courses of action and the motivational states they engender. Can the actions of the interests themselves be economically modeled at the intentional level? Is Ainslie’s picoeconomics entirely a cognitive theory or does it lend itself to microeconomic analysis? In fact, [Ross (2012)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B84) puts forward an array of economic models of the strategic interactions proposed by picoeconomics among competing preferences. Analysis of neurodecision Managerial economic behaviour in terms of the pattern of reinforcement it has previously resulted in draws upon operant neurodecision Managerial economic behavioural economics which is central to the MEBDS: specifically, the analysis of discounting relates neurodecision Managerial economic behaviour to its consequences, but operant neurodecision Managerial economic behavioural economics also establishes that individuals maximize utility and the particular combinations of reinforcement that constitute utility.

It is particularly important from the point of view of the research program within which the current investigation is being performed (see [Foxall, 2007a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B48)) that the cognitive interpretation of neurodecision Managerial economic behaviour, here picoeconomics, can be defended philosophically in terms of the underlying neurodecision Managerial economic behavioural and neuroscience ([Foxall, 2004](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B47)). This is clearly the case with picoeconomics ([Foxall, 2007b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B49)). Now that picoeconomics has been established as a cognitive component for neuro-neurodecision Managerial economic behavioural decision theory, its usefulness as a means of overcoming Managerial dysfunction with respect to temporal horizon can be evaluated. As Section Organisation-Level Strategies for Changing Managerial Neurodecision Managerial economic behaviour indicates, the general thrust of picoeconomics is towards clinical application that may not fit most Managerial situations. In that case, alternative approaches to management are discussed, notably adaption-innovation theory, which are founded on similar neurophysiological bases but which suggest more practicable solutions.

An advantage of picoeconomics in the current context is that it suggests means of overcoming the Managerial problems likely to arise when individual Managers are strongly motivated by the goals and neurodecision Managerial economic behavioural patterns that reflect hyperactivity in the impulsive system and hypoactivity in the executive system. [Ainslie (1992)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B1)proposes a number of strategies through which the individual might overcome the temporal discounting that is the hallmark of this tendency. It is here that RST underpins the current analysis by providing neurophysiological systems that underlie not only the more extreme impulsive—approach tendency (BAS) the fear—engendered escape—avoidance tendency (FFFS), but the goal-resolving tendency that seeks to reconcile the alternative courses of action (BIS). The strategies of self-control suggested by Ainslie can be seen as attempts to aid the BIS in its attempts at conflict-resolution.

[Ainslie (1992)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B1) proposes four personal strategies, allusion to some of which was made above, by which the individual might make a larger, albeit longer-term, outcome more probable: precommitment, control of attention, preparation of emotion and reward bundling. Precommitment involves using external commitments to preclude the irrational decision. The individual seeks to manipulate the external environment in order to make neurodecision Managerial economic behaviour leading to the LLR more likely. Ulysses lashed himself to the mast before temptations arose. But precommitment need not be so dramatic. An addict may imbibe a substance that induces nausea when alcohol is drunk. A student might arrange for friends to take her to the library before a favourite TV program begins. Control of attention restricts information processing with respect to the SSR. For example, taking a route home from the office that avoids bars or fast-food restaurants; thinking about the car one can buy if you eliminate cigarette smoking. Preparation of emotion may take the form of inhibiting emotions that are customarily connected with the SSR or of increasing incompatible emotions. Hence, graphically recalling the health risks of over-eating, smoking or excessive alcohol consumption, thinking of the displeasure others will show, engage cognitive reasoning in order to eliminate the emotional anticipation that customarily lead to consumption.

Perhaps the principal strategy, reward bundling requires the individual to make personal rules about the perception of the smaller-sooner and larger-later decisions available. Instead of imagining the present decision and its exciting outcomes (drinking alcohol to excess) as opposed to a single somewhat amorphous outcome of sobriety (‘longer life’), reward bundling involves bring a whole sequence of larger- later rewards to oppose rewards of the immediately-available neurodecision Managerial economic behaviour. In the absence of such bundling, the individual is likely to undergo repeated preference reversals but viewing the decision as between two streams of neurodecision Managerial economic behaviours and outcomes makes self-control more possible. Self-control results from perceiving a single decision between an aggregation of LLRs and a competing aggregation of SSRs. The sum of the LLRs is always greater than that of the SSRs. Decision making is then a matter of imaginatively bringing the LLRs forward in time to the present. The personal rules necessary to ensure this self-control take the form of private ‘side-bets’ in which the current decision predicts future decisions. The important point in viewing the reward sequences in this way is that the LLR is at all times superior to the SSR even when an SSR is immediately available: preference reversal is therefore not predictable. The rule is a side bet that the current decision will predict future decisions. If the SSR is resisted, the bet is won: the expectation of future reward is thus enhanced and the individual’s probability of success in resisting temptation is increased. Selection of the SSR indicates that the individual has lost the bet, however: the individual’s self-image is weakened, along with his or her expectation of resisting the temptation in the future.

The relevance of these strategies to Managerial decision-making of the kind we have been discussing is evident though it is unclear whether a Manager would be able to recognize and change his or her neurodecision Managerial economic behaviour in the absence of detailed one-on-one counseling. While this methodology obviously has applications in therapeutic contexts, and Ainslie’s prescriptions fit well the needs of substance and neurodecision Managerial economic behavioural addicts, an application that is more attuned to the social-structural demands of organisational management is called for in the context with which we are here concerned.

There exists an alternative approach to Managerial application of the neuropsychological work that has been reviewed in this thesis, though the following comments are indicative and call for a dedicated research program. Adaption-innovation theory ([Kirton, 2003](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B63)) suggests a means of structuring decision-making groups that reflects competing neuro-neurodecision Managerial economic behavioural systems and so avoids reliance on an individual-level prescription for Managerial neurodecision Managerial economic behaviour. ‘Cognitive style’ refers to a person’s persistent preferred manner of making decisions, the characteristic way in which they approach problems, information gathering and processing, and the kinds of solution they are likely to work towards an attempt to implement. As such, it is orthogonal to cognitive level, which is intelligence or capacity. [Kirton (2003)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B63)proposes that individuals’ cognitive styles can be arrayed on a continuum from those that predispose ‘doing better’ (the adaptive pole) to those that predispose ‘doing differently’ (the innovative pole). Adaption-innovation is measured by the Kirton Adaption-Innovation Inventory (KAI) which evinces high levels of reliability and validity and scores correlate with a number of personality variables including extraversion and impulsivity. General population samples indicate that trait adaption-innovation is approximately normally distributed and general population scores, including of course those of Managers, are arrayed over a limited continuum which falls within the theoretical spectrum of scores posited by adaption-innovation theory. In line with the purview of this thesis, therefore, the Managers of whom we speak are not extreme in their neurodecision Managerial economic behaviours, though they some of them may exhibit scores towards the extremes of the bipolar construct of adaption-innovation. The neurodecision Managerial economic behaviour of the extreme adaptor is generally characterized by a tendency towards caution in decision-making and problem-solving, use of tried-and-tested methods, efficiency, rule-conformity and limited quantitative creativity manifesting in the generation of relatively few, workable solutions. The extreme innovator is, in contrast, more outlandish in selecting decisions, more likely to propose novel solutions to problems (many of which are impracticable), less efficient and more likely to modify or even break the rules. Although extraversion (measured, for example, by Eysenck’s E scale) emerges as more highly correlated with adaption-innovation (measured in the direction of the innovativeness pole), little is known about the underlying personality profiles of adaptive and innovative decision-makers in relation to the contingencies of reinforcement that shape and maintain their preferred neurodecision Managerial economic behavioural styles. RST ([Gray and McNaughton, 2000](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B57);[McNaughton and Corr, 2004](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B72); [Corr, 2008a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B36)) offers a means of investigating the personality profiles of decision-makers and the role of reward and punishment in their development and maintenance. This all suggests that a psychometric research program concerned with the integration of a number of fields could provide indicators for the prescription to the problems of extreme Managerial style. The program would need to encompass the neurophysiology of cognition together with the psychometric measurement of personality dimensions that underlie cognitive style. Enough has been said to indicate that we understand these fields and their interactions sufficiently to embark on such a program. In the meantime, the following remarks are indicative of the work that needs to be undertaken.

In contradistinction to innovators, adapters are typically prudent, using tried and tested methods, cautious, apparently impervious to boredom and unwilling to bend, let alone break, the rules. They seek the kind of efficiency that manifests in accomplishing known tasks more effectively. An extremely adaptive cognitive style suggests hyperactivity of the executive system coupled with hypoactivity of the impulsive system. Moreover, those aspects of the executive system that involve ToM, the observation of social conventions, meta-cognition, and some facets of neurodecision Managerial economic behavioural flexibility might be adaptor characteristics that would confirm this categorization. The tentative conclusion is that adaptors would cope well and perform advantageously when involved in the intellectual, long-term, detailed thinking that strategic planning requires. The downside to their over-involvement in this kind of decision-making derives from the demands that strategic planning and commitment sometimes exert upon the ability to undertake ‘outside-the-paradigm’ thinking. Such demands are likely to be, relatively, occasional but they are equally likely to arise at times of crisis in the market and competitive environments of firms and to benefit most from the kind of thinking which characterizes a more innovative cognitive style. In contradistinction to adaptors, innovators typically proliferate ideas that require the relatively radical change that can modify strategic direction, the product-market scope of the firm, and possibly diversification. At its extreme however, this cognitive style, suggests hypoactivity of the executive system, hyperactivity of the impulsive system. The impulsive system is geared to the rapid identification and evaluation of opportunities and threats, the capacity to envisage far-reaching, possibly disruptive, change which, in refocusing the entire strategic scope of the enterprise carries with it upheaval in working practices and both the working and non-working lives of Managers and other employees. To the extent that these are innovator-traits, it is clear that decision groups need to be balanced by adaptors who can supply the capacity for sounder decision-making and the facilitators who can explain to innovators the rationale behind the neurodecision Managerial economic behaviour of adaptors, who are otherwise likely to be seen as too slow-moving to respond appropriately to the crisis, and to adaptors that which underpins the neurodecision Managerial economic behaviour of innovators who would otherwise be perceived as too outlandish to preserve the values of the organisation. Innovators supply strengths in organisational decision-making: they are more likely to think outside the paradigm within which a problem has arisen, unconfined by the tried and tested methods currently in place, and to take risks. These are all relevant when the organisation faces grave uncertainties and requires radical strategic reorganisation. But innovators may be unsuited to more short-term decision-making which requires the skills of prudence and caution which are the hallmark of the adapter.

Normally, strategic thinking and planning require the adventurous outlook of the innovator, tempered by the prudence of the adapter. But, without top management vigilance and the planning of the teams that participate in decision-making, it might well attract a preponderance of extreme adapters. If this cognitive style dominates the strategic function, there is likely to be a dysfunctional emphasis on the planning of strategy at the expense of the taking of strategic decisions and the implementation of appropriate policies at the operational and administrative levels. Insofar as strategic decisions are unprogrammed, they therefore require the inputs of innovators. So a prolonged predominance of adapters in this role will lead to organisational imbalance. Normally, operational (and administrative) functions require the efficient involvement of the adapter, tempered by the more outward-looking tendency of the innovator. But, again without top management vigilance, they might attract the extreme innovator who seeks to take risks for short-term benefits. This will interfere with the strategic management of the enterprise and could jeopardize the overall operation of the firm.

‘Strategic’ decisions do not necessarily arise at a Managerial level that is automatically higher than that of any other kind of decision, nor do strategic decisions inherently involve the breaking of paradigms, and innovativeness. Just because strategy involves long-range planning does not preclude its occurring within a paradigm, albeit of grand scope, that is nevertheless known and generally-accepted; equally, the innovativeness of eroding boundaries between small-scale organisational systems should not be automatically diminished ([Jablokow, 2005](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B60)). Adaptive and innovative styles of cognition and creativity are constantly required, alongside one another, in the solving of problems. That which predominates appropriately in any given situation depends entirely on the specific context. Organisational problems arise when current strategies no longer fit the demands of the organisational environment: when markets, reflecting demand and competition, are no longer adequately served by the norms of organisational neurodecision Managerial economic behaviour ([Jablokow and Kirton, 2009](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B61)). Such changing circumstances have two vital components. The first is the changing environment must be perceived as involving precipitating events, i.e., the need for change by the organisation’s leaders; it is adaptors rather than innovators who are more adept at detecting unforeseen developments that require Managerial action. The second is the exploitation of the opportunities such external change is prompting, or the defensive action needed to avoid the threats that the environment contains; these tasks of advancing the required action are more likely taken effectively by the more innovative ([Tubbs et al., 2012](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B101)). This is a matter of cognitive style, not of cognitive or decision level.This point is summarized by the ‘paradox of structure’ ([Kirton, 2003](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B63), pp. 126–134): while Managers require structure whatever their cognitive style, but that structure is ultimately stultifying as persons, organisations and environments exhibit dynamic neurodecision Managerial economic behaviours. All the more reason for founding Managerial teams and neurodecision Managerial economic behaviour patterns on the contributions of all cognitive styles.

[Van der Molen (1994)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B102) notes on the basis of evolutionary logic that social animals are motivated by two counterpoised tendencies: first, to find satisfaction in the company of specifics which requires a degree of cooperation and conformity; secondly, to compete with specifics for limited resources, such as food, sexual partners, and territory, on which individual survival and biological fitness rely. The personality characteristics which reflect these motivational forces are, in turn, ‘strongly intercorrelated’ traits such as ‘self-will, thing-orientation, individualism and innovative creativity on the one pole and compliance, person-orientation, sociability, conformity and creative adaptiveness on the other. Individuals differ from one another as far as the balance between these polarities [is] concerned. This variation between individuals must have genetic components’ ([van der Molen; 1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B102)).

Drawing on the work of [Cloninger (1986](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B33), [1987](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B34)), [van der Molen (1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B102)) makes a strong case for the evolutionary and genetic components of adaption innovation. Cloninger’s ‘novelty-seeking’ and ‘reward dependence’ dimensions of personality are especially pertinent. The former is driven predominantly by the neurotransmitter DA which manifests in neurodecision Managerial economic behaviour that seeks to alleviate boredom and monotony, to deliver the sense of exhilaration and excitement that is generally termed ‘sensation-seeking’ ([Zuckerman, 1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B110)); these individuals demonstrate a tendency to be ‘impulsive, quick-tempered and disorderly… quickly distracted or bored… easily provoked to prepare for flight or fight’ ([van der Molen, 1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B102), p. 151). ‘Reward dependent’ individuals are, in contrast, highly dependent on ‘social reward and approval, sentiment and succour’; they are ‘eager to help and please others, persistent, industrious, warmly sympathetic, sentimental, and sensitive to social cues, praise and personal succour, but also able to delay gratification with the expectation of eventually being socially rewarded’ (ibid). These individuals’ neurodecision Managerial economic behaviour is strongly controlled by neither monoamine neuromodulatory nor epinephrine.

Which of these bundles of attributes manifests in neurodecision Managerial economic behaviour that marks out some individuals as leaders depends entirely on the demands of the Managerial situation: retail banking, relying for the most part on the implementation of standard operating procedures, may have a natural tendency to encourage and reward those neurodecision Managerial economic behaviours that reflect an adaptive cognitive style; pharmaceutical companies, whose technological, demand and competitive environments reflect a greater dynamism than is ordinarily the norm for retail banking, requires for a much larger part of its activities the presence of individuals whose cognitive and creative styles are predominantly innovative. Investment banking which is expected to reflect a large adaptively-creative style of operation but which attracts innovators is in danger of becoming the kind of ‘casino banking’ that has been so deleterious to both corporate and general social welfare in the last decade. But the inability of an organisation to achieve the right cognitive and creative accommodation to its environment will predictably culminate in catastrophe. For the retail bank whose leaders fail to perceive and respond appropriately to the changing international competition in high-street banking, the pharmaceutical firm that becomes over-involved in the development and marketing of drugs that are novel in the extreme, and for the investment bank that over-emphasizes innovative creativity to the point where reckless decisions are made, catastrophe is equally probable. Predominant organisational climate, adaptive or innovative, can be disastrous if either of these cognitive styles comes to predominate.

These neurodecision Managerial economic behavioural styles are remarkably consonant the innovative and adaptive cognitive/creative styles, respectively, described by [Kirton (2003)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B63). Their prevalence and likely genetic basis is borne out by their consistency with the RST described above ([Corr, 2008a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B36); see also [Eysenck, 2006](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B45)), though the terminology may vary. The incorporation of adaption-innovation theory into the framework of conceptualization and analysis also suggests a wider search for the neurophysiological basis of styles of creativity. But these are matters for further research.

Analyses of Managerial neurodecision Managerial economic behaviour in neurophysiological terms raise two difficulties. The first is conceptual: such explanations conflate cognitive processes with neurophysiological events; the second relates to practical management: such explanations offer little by way of solution to the personal and organisational problems that result from neurodecision Managerial economic behaviour that is motivated by excess influence of either Managers’ impulsive systems or their executive systems. This thesis has sought to contribute to the resolution of the conceptual problem, by introducing a cognitive dimension, picoeconomics, into neuro-neurodecision Managerial economic behavioural decision theory, and the adaption - innovation theory of cognitive styles to that of the practical problem by deriving prescriptions for changing Managerial neurodecision Managerial economic behaviour.

The prime conclusion is that the use of neurophysiological theory and research in the conceptualization of Managerial decision-making and in approaching the solution of problems that arise therein is entirely justified but needs to be qualified by practical considerations suggested by the nature of Managerial work and the ways in which Managerial neurodecision Managerial economic behaviour can be modified especially in the context of large-scale organisations. Prior to such activity, however, is the resolution of conceptual problems in the explanation of individual neurodecision Managerial economic behaviour on the basis of neurophysiological events. This thesis has pursued a central requirement of neuro-neurodecision Managerial economic behavioural decision theory’s use of intentional terminology to explain human neurodecision Managerial economic behaviour: the role of cognitive terminology and its implication for the shape of the overall theory. It has argued that picoeconomics provides a valuable means of inculcating a cognitive level of explanation into the theory and that one of its advantages is that it suggests solutions to hyperactivity in one or other of the impulsive and executive systems identified by the theory which is exacerbated by hypoactivity in the alternative system. The solutions proposed by picoeconomics may, however, be most suitable for remedial action in clinical settings rather than in organisational settings. The quest for solutions to Managerial problems is more readily achieved through organisation-level models of Managerial activity that incorporate as fully as possible neurophysiological understandings of neurodecision Managerial economic behaviour that are compatible with those found in neuro-neurodecision Managerial economic behavioural decision theory. One possibility in the present context is the application of adaption-innovation theory, dimensions of which are known to map reliably on to the neurophysiological and cognitive/personality factors that underpin impulsive and executive systems. The proposal that Managerial teams be built and managed in ways that reflect these considerations suggests the most relevant applications of neuro- and neurodecision Managerial economic behavioural science, with cognitive psychology, for the remediation of certain Managerial excesses. These conclusions lead predictably to a call for further research along the lines indicated.

The advantage of this emphasis on cognitive style is that it differentiates Managers on the basis of their susceptibility to hyper- or hypo-activity of either the impulsive or executive systems; and recognizing that the Managerial functions with which we are concerned are populated by Managers of widely differing cognitive styles should reduce our tendencies to stereotype Managers on the basis of their broadly-defined functional roles ([Foxall and Hackett, 1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B53); [Foxall and Minkes, 1996](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B54)). The neurophysiological foundations of adaption-innovation as presented here do not map directly on to those of RST or neuro-neurodecision Managerial economic behavioural decision theory. But there is sufficient overlap to motivate further investigation.

**Human Brain Tectonics**

Human resources rely on cautious mock-up of neuroManagerial economic decision making modeling. Tactic consists in construction models to display relationship between cause and neuro incongruity. Freedom provided by introspection technique leads to a model selection problem. Neuro - management neuroManagerial economic decision making-making, regarded as a mental process (cognitive process), result in selection of path of action among alternative circumstances. Each neuroManagerial economic decision making-making process produces neuroManagerial economic decision making. Process is regarded as incessant process integrated with situation. Investigation is concerned with rationale of neuroManagerial economic decision making -making, reasonableness and invariant neuroManagerial economic decision making. These reflect compensatory interface of neuroManagerial economic decision making -related expanse. Specific brain structure potentiates neuroManagerial economic decision making - makings depending on strategy, traits and framework. Therefore, neuroManagerial economic decision making is a reasoning or emotional process which can be rational or irrational, based on explicit / tacit assumptions. This leads to formulation of a ‘neuro - management neuroManagerial economic decision making paradox’. Explorations on brain mechanisms juxtapose link between brain and behaviour, known as Cognitive Neuroscience, to study neuronal activities, connections between neurons, plasticity of brain and relationship between brain and behaviour. These inherit methods as how brain encodes, processes information, stores representation in mind to craft actions in reaction to stimuli. These embrace sensation and perception of information, interface linking information in dissimilar modalities, matrix of memory and dispensation of information. Deduction is based on postulation that individual cognitive functions are based on neural activities in brain.

Researchers argue that humans make neuroManagerial economic decision making by obeying laws of judgment. Expected efficacy argument has dominated understanding by assuming that under circumstances, human beings make neuroManagerial economic decision making and inclination by maximizing efficacy. Nevertheless, in observing behaviours, they do not link cerebral scrutiny to decide which inclination to formulate. This holds proper for uncertain and non-risky neuroManagerial economic decision making. Neuroscience plays role to understand brain in reason of behaviours. Arguments include Prospect Theory, Somatic Marker argument and Magnetic Resonance Imaging (MRI) techniques to measure neuro waves. Key problems include how brain represents value of diverse inclinations capitulate best possible neuroManagerial economic decision making. Which are the limits for testability in neuroManagerial economic decision making-making experimentation? Could we experiment neuroManagerial economic decision making-making flawlessly mimicking valid contexts? Is top -down control involved? Do we have liberated will and to what extent we have room for inclination, if any? Key limitation is that it is able to spot different regions of brain in definite situations. These do not offer clarification or explain (behavioural). Experimental methodology assists in understanding as to why human beings make inclinations. Arguments happen to be significant in understanding human neuroManagerial economic decision making.

NeuroManagerial economic decision making involves detection of need, discontent within oneself, decision making to change and mindful perseverance to execute decision making. How are neuroManagerial economic decision making carried out in brain? What are the general implications? Primary argument is that neuroManagerial economic decision making-making is coupled with factors of uncertainties, compound objectives, interactive intricacy and apprehension that makes neuroManagerial economic decision making-making course of action difficult. There is the requirement for strategic neuroManagerial economic decision making-making. Questions include; how to choose in situations where stakes are high with multiple conflicting objectives? How to plan for dealing with risks and uncertainties involved? How to craft options better than originally available? How to become better neuroManagerial economic decision making makers? What resources will be invested? What would be the potential responses? Who will make this neuroManagerial economic decision making? How should they be evaluated? How will one decide? Which of the things that could happen would happen? How can we ensure neuroManagerial economic decision making will be carried out? These questions are crucial for understanding complex human behaviours.

The human brain is the most complex organ in the body. The human brain is one of the most complex objects of scientific research. Understanding the brain, its cognitive functions, and the related conscious experience requires cooperation of quite a number of different disciplines. The number of connections in the brain exceeds the number of atoms in the universe. The brain is foremost a control structure that builds an inner illustration of outer world and uses this depiction to make decision, goals and priorities, formulate plans and be in charge of activities with objective to attain its goals. Cognitive Neuroscience relies on non-invasive techniques to look at neural activities at different brain regions when Managers perform cognitive tasks. The techniques offer information concerning brain activity during diverse cognitive processes but not about underlying relationship linking brain expanse and cognitive functions. It is mysterious whether activities in brain regions are essential to analogous cognitive functions. These have confines.

All sciences are now under the obligation to prepare the ground for the future task of the philosopher, which is to solve the problem of value, to determine the true hierarchy of values. **Value** is arguably one of the most central concepts governing human life, as it is involved in practically every aspect that requires a decision: whether we choose between different consumer goods, whether we decide which person we marry or which political candidate gets our vote, whether we ask ourselves if something is beautiful, morally right, or sacred, value plays a crucial role. Value reflects the importance that something holds for us, what doesn't have any value is of no interest. Consistent with the central role of value in our lives, ever since Plato scholars have been trying to understand what value is and where it comes from. Today, the investigation of value is central to many disciplines studying human feeling, thinking and behaviour, such as philosophy, psychology, sociology, economics, or neuroscience Value plays a central role in practically every aspect of human life that requires a decision. Over the last decade, neuroeconomic research has mapped the neural substrates of economic value, revealing that activation in brain regions such as ventromedial prefrontal cortex (VMPFC), ventral striatum or posterior cingulate cortex reflects how much an individual values an option and which of several options he/she will choose. However, while great progress has been made exploring the mechanisms underlying concrete decisions, neuroeconomic research has been less concerned with the questions of why Managers value what they value, and why different Managers value different things. Social psychologists and sociologists have long been interested in core values, motivational constructs that are intrinsically linked to the self-schema and are used to guide actions and decisions across different situations and different time points. Core value may thus be an important determinant of individual differences in economic value computation and decision-making. Based on a review of recent neuroimaging studies investigating the neural representation of core values and their interactions with neural systems representing economic value, we outline a common framework that integrates the core value concept and neuroeconomic research on value-based decision-making.

Research on economic value has produced many insights into the neurocognitive mechanisms that drive decisions in concrete situations, whereas research on core value allows explaining inter-individual differences in decision situations as well as intra-individual consistency across decisions over time. Whereas these different facets of the value concept so far have been investigated more or less in isolation from each other, we feel that an integration of the two perspectives would be extremely useful. In this contribution we review (a) neuroeconomic research delineating the neurocognitive mechanisms underlying economic value computations and (b) social psychological and sociological research concerning the universal structure of core values and the role of individual core value differences in decisions and behaviours. We then propose a common framework that aims at integrating the core value concept into a neuroscience of decision-making, and support our idea by a review of recent neuroimaging studies investigating the neural representation of core values and their potential interactions with neural mechanisms underlying value computation and decision-making.

Over the last decade, the brain network representing economic value has been delineated using neuroimaging methods (Padoa-Schioppa and Assad, [2006](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B44); Schultz,[2006](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B56); Kable and Glimcher, [2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B26); Grabenhorst and Rolls, [2011](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B18); Padoa-Schioppa, [2011](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B43); Rushworth et al., [2011](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B52); Lee et al., [2012](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B30); Levy and Glimcher, [2012](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B31)) as well as single neuron recordings (in primates, Platt and Glimcher, [1999](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B46); Tremblay and Schultz, [1999](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B62)). In a typical neuroimaging experiment, participants view different stimuli (for example different consumer objects) and are asked to choose one of them (or to indicate how much they like each option). The individual decisions (or preferences) are then used to derive a measure of economic value, which is used as a parametric regressor to identify brain regions that show systematic activation changes as a function of the value of the presented objects. A large number of converging studies have identified a network of brain areas representing subjective economic value for many different types of rewarding stimuli, consisting of ventromedial prefrontal cortex/orbitofrontal cortex (VMFPC/OFC), ventral striatum, posterior cingulate cortex, amygdala, insula and posterior parietal cortex (see, e.g., Kawabata and Zeki, [2004](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B27); O'Doherty, [2004](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B41); Kim et al., [2011](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B28); Levy and Glimcher, [2012](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B31)).

Studies comparing neural activation to different classes of rewarding stimuli in the same subjects (e.g., to food, consumer goods, money, or social reputation gains) have observed overlapping activations in VMPFC/OFC, striatum, and insula, suggesting that these regions indeed represent a common currency for different types of rewarding stimuli that allows comparing and deciding between objects with very different properties (Izuma et al., [2008](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B24); Chib et al., [2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B8); Grabenhorst et al., [2010](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B17); Kim et al., [2011](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B28); Lin et al., [2012](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B34)). This neural system representing economic value can implement computations of considerable complexity, such as a cost-benefit analysis (when participants are choosing between options that imply both rewarding and punishing aspects) in interactions of VMPFC/OFC and insula (Talmi et al.,[2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B61)), and value discounting during delay of gratification (when participants are choosing between a smaller reward right now and a higher reward later) in VMPFC/OFC and ventral striatum (McClure et al., [2004](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B36)).

Activation in this network should thus allow to infer preferences and to predict decisions: When two different objects elicit neural activation of equal magnitude, the two objects should be equally desirable for a person. In contrast, when activation is increased toward one object compared to another, this object should be preferred. And indeed, measurements of brain activation in regions of this network allow predicting which of two items an individual prefers and chooses, at least when the subjective value difference between the two items is fairly large (FitzGerald ; [2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B15) and Levy ; [2011](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B32)).

To sum up, neuroeconomic research has reliably identified a brain network representing economic value that allows predicting individual preferences and decisions. However, whereas much progress has been made identifying the neurocognitive mechanisms underlying concrete decisions, neuroeconomic research has mostly neglected questions such as why Managers choose (and thus value) what they choose, or why different Managers choose (and thus value) different things. At the proximal level, this question has been addressed by looking at the impact of individual reinforcement learning histories (see Lee et al., [2012](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B30), for a review) However, more research on the distal motivational principles that can predict decisions across situations is clearly needed. Moreover, neuroeconomic research is largely restricted to relatively simple decisions, such as decisions between two consumer goods, and rarely investigates more complex decisions and life decisions. Such issues are however addressed by researchers interested in core value, mainly from social psychology and sociology. In the following section, we will summarize some key concepts and findings from this field.

Core value refers to stable motivational constructs or beliefs about desirable end states that transcend specific situations and guide the selection or evaluation of behaviours and events (Rohan, [2000](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B50)). An individual's core values form an internal compass that Managers refer to when they are asked to explain and justify their preferences, decisions, or behaviours. For example, a person may frequently donate money to charitable causes and explain this behaviour by their altruistic core values. Core values are thus instrumental in providing the individual with meaning in the world. They provide an organisational principle for an individual's self-schema (Roccas ; [2002](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B49)), forming the core of one's identity (Hitlin, [2003](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B22)).

Importantly, core values are not only used to give orientation and stability to the self, but allow predicting individual differences in concrete decisions and behaviours. For example, a person emphasizing conservation-related values more frequently observes traditional customs on religious holidays than a person who does not hold these values in high esteem. A person who emphasizes self-transcending values more frequently uses environmentally friendly products than a person who emphasizes self-enhancing values (Bardi and Schwartz, [2003](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B3)). Core value differences have furthermore been shown to be powerful predictors of voting behaviour (Schwartz et al., [2010](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B58)). Thus, the core value concept is a powerful construct that may explain why different Managers value different things and why different Managers choose differently in the same situation, and thus may be fruitfully combined with neuroeconomic research on value computation and decision-making.

However, so far not much research has attempted to investigate the neural mechanisms underlying the role of core value in decision-making. In a first attempt to integrate core value into current neuroimaging research, we aimed at identifying the neural regions involved in the representation of core value (Brosch ; [2012](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B6)). To this end, we showed our participants examples of behaviours that reflect different core values and asked them to indicate on a scale from 1 to 4 how important the behaviour (and thus the related core value) is for them (core value condition). In order to directly compare the neural regions representing core value to the regions representing economic value, these behaviours were intermixed with examples of potentially rewarding concrete activities (such as ‘eating an apple,’ ‘playing tennis’), for which participants indicated (using the same scale from 1 to 4) how much they like performing this activity (economic value condition). The economic value condition activated the expected neuroeconomic value network, including regions such as VMPFC, posterior cingulate cortex, and posterior parietal cortex. In contrast, the core value condition led to increased activation in medial prefrontal cortex (MPFC) and in the dorsal striatum. MPFC has frequently been linked to processes involving self-reflection (Macrae et al., [2004](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B35); Northoff and Bermpohl, [2004](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B40); Mitchell et al., [2005](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B37); Lieberman, [2010](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B33)), both when explicitly reflecting about one's self and when implicitly processing self-related information (Rameson et al., [2010](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B47)), and has furthermore been shown to be activated when thinking about future goals, which are closely tied to one's core values (D'Argembeau et al., [2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B10)). The observed activation of MPFC is thus consistent with the conceptualization of core value as an integral part of the self-schema (Hitlin, [2003](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B22)). However, given that so far this is the only neuroimaging study linking core value to MPFC, it would be important to replicate this finding in future studies.

As outlined in the previous sections, economic value and core value both refer to evaluative representations that guide decisions and behaviours. They are however conceptualized at different levels of situational concreteness, with economic value referring to a common currency that operates in concrete decision situations, and core value referring to motivational constructs that guide decisions and behaviours across many situations. Despite the conceptual similarities, there has not been much integration and cross-fertilization between the two research traditions. We suggest combining the two value concepts into a common framework for decision-making. In linking these two concepts, neuroeconomic research may be enriched by an elaborate and empirically validated concept that allows predicting and explaining individual differences in value-based decision-making. Furthermore, integrating the set of core values and the related behaviours into neuroeconomic research goes beyond the kind of decisions that are usually investigated empirically, moving from simple decisions between consumer goods to a more diverse and complex array of decisions. In return, core value research may gain a deeper understanding of the underlying mechanisms by which core values impact on decisions and behaviours. In this context, several core value researchers have suggested that the effects of core value on decisions and behaviours are relatively indirect, being exerted by changing the beliefs and norms of the individual (Dietz et al., [2005](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B13)) or by exploiting one's need for consistency between beliefs and actions (Rokeach;[1973](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B51)).

Here we want to evaluate the possibility that, in addition to these indirect effects, a more direct connection links core value, economic value, decision-making and behaviour. Our hypothesis is that individual differences in core value may be determinants of how much economic value is given to the different options in concrete decision situations. Thus, the behavioural effects of core value differences may—at least partly—be implemented by neural mechanisms underlying the computation of economic value. In what follows, we will review the relevant neuroimaging evidence against which our hypothesis can be evaluated. Whereas to our knowledge only two studies have so far directly addressed the impact of core values on neural activation (Brosch et al., [2011](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B5), [2012](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B6)), a number of other neuroeconomic studies have investigated the neural correlates of a specific behaviour that is relevant to the core value dimension of self-enhancement vs. self-transcendence: egoistic vs. altruistic behaviour expressed by charitable donations. The first neuroimaging study to investigate the neural correlates of charitable donations (Moll et al., [2006](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B38)) presented participants with a series of decisions on whether to donate money to a charitable organisation related to a major societal cause (such as children's rights, gender equality, or nuclear power). In other trials, participants received money for themselves. Results revealed increased activation of the striatum, a central part of the neural system representing economic value, both when participants received money for themselves and when they decided to donate for a good cause. In further research, the perceived value of charitable donations has been shown to be represented in VMPFC/OFC as well (Hare et al., [2010](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B20)). Taken together, these findings suggest that receiving money and donating money are both rewarding experiences, as expressed by a shared anatomical system of value representation. These findings were extended by demonstrating that increased striatal responses to charitable money transfers also occur when the transfer is mandatory (similar to an income tax), but that the striatal response is even higher when Managers voluntarily decide to make a donation (Harbaugh et al., [2007](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B19)). In another study, participants were matched into pairs and presented with a series of unequal monetary distributions, where one participant received a large monetary endowment and the other one nothing (Tricomi et al., [2010](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B63)). Participant who had already received a lot of money in previous trials showed a stronger neural response in VMPFC/OFC and ventral striatum when they observed a money transfer to the other participant (who had previously received less money), compared to when they received money themselves, indicating that the neural value regions also represent value related to distributive fairness. Finally, in a study on moral dilemmas, participants were confronted with scenarios where they had to make decisions that sacrificed the lives of some Managers in order to save others. The expected ‘moral reward value’ (i.e., the ratio of lives saved/lost) was tracked by VMPFC/OFC and ventral striatum, suggesting that decisions based on self-transcending values may involve the same neural systems that represent economic value (Shenhav and Greene, [2010](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B60)). Taken together, these results suggest that the neural regions representing economic value are involved in decisions and behaviours that are related to core values.

But are individual differences in the activation of these regions related to actual differences in altruistic decisions and behaviours? In the taxation-donation study by Harbough and colleagues described above, participants who showed a stronger striatal response when receiving money for themselves opted less frequently to donate money to charity (Harbaugh et al., [2007](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B19)). Furthermore, in a study looking at individual differences in preferences for distributive fairness, participants who generally choose equal distributions of money showed increased amygdala activation when confronted with very uneven distributions (Haruno and Frith, [2010](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B21)). These two studies suggest that behavioural differences that are relevant to core values may indeed be driven by differences in activation of neuroeconomic value regions.

As a final step in our argumentative chain, it remains to be shown that different neural activation patterns in economic value regions are actually related to individual differences in the core value hierarchy. To address this issue, we measured the core value hierarchies of individuals who participated in a donation task (Brosch et al., [2011](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\Neurocognitive%20mechanisms%20underlying%20value-based%20decision-making%20%20from%20core%20values%20to%20economic%20value.htm#B5)). In some trials, participants could gain money for themselves; in other trials they decided whether they wanted to donate some of their money to charity. Analysis of the decisions made during the task showed that participants with self-centered core value hierarchies donated less money to charity, demonstrating that more self-interested core values are actually reflected in more selfish behaviour (see Figure [​Figure2).2](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3721023/figure/F2/)). At the neural level, all our participants showed increased activation of the striatum when receiving money. However, the activation was more pronounced for participants with a more self-centered core value hierarchy, suggesting that egoistic behaviour is potentially more rewarding for participants with self-centered core values than for less self-centered participants.

I have distinguished between the empirical and conceptual criteria of informed consent. Empirical criteria rely on the psychological and neural processes of decision making involved in informed consent. Here the ‘human black box’ itself is the focus of investigation because it is considered to be necessary and sufficient for generating the respective psychological and neural processes. The ‘human black box’ in decision making is characterised by an exclusive focus on the physical processes within the ‘human black box’ itself remaining isolated from its respective environmental context. One can subsequently speak of an ‘isolated ‘human black box’’. Since a naturalistic explanation relies exclusively on physical (that is, empirical) criteria, a naturalised concept of informed consent in terms of decision making presupposes the ‘human black box’ to be an isolated ‘human black box’. Empirical criteria remain purely descriptive by themselves and therefore do not imply any norms and values; instead, they are provided by conceptual criteria being normative. These norms and values are reflected in our concept of informed consent, which therefore cannot be identified with the merely empirical function of decision making. Any debate of norms and values is possible only when one considers the respective cultural and social context; that is, the environment. Since it refers to norms and values, informed consent, unlike decision making, presupposes a relationship to the respective environmental context. If one wants to associate informed consent with the ‘human black box’, one should therefore consider the ‘human black box’ in relation to its environment; that is, as an ‘embedded ‘human black box’’.

A naturalistic explanation presupposes identification of the ‘human black box’ of decision making with the ‘human black box’ of informed consent. This poses an ethical dilemma, with two alternative ways of acting when there is impaired consent that are both ethically unacceptable. Researchers call this dilemma ‘the ethical dilemma of impaired consent’. In the case of a neuropsychiatric disorder, the ‘human black box’ of decision making needs to be treated and must thus be considered as the target organ for therapy. In contrast, the ‘human black box’ of informed consent is essential for giving approval to such treatment and could thus be considered the organ of informed consent. If, however, the ‘human black box’ of decision making and the ‘human black box’ of informed consent are presupposed to be identical, as implied in a naturalistic explanation, the following alternatives arise. Either the ‘human black box’ of decision making as the organ of therapy must be treated without any consent (unless relatives give consent) because, owing to its identification with the organ of informed consent, consent cannot be given without prior therapy. However, treatment without valid informed consent is non‐acceptable ethically (except in life‐threatening situations). Alternatively, the ‘human black box’ of decision making remains untreated because valid informed consent cannot be obtained. However, non‐treatment of the patient’s symptoms and his or her deficits in decision making must also be considered unethical. Since either way of acting—treatment or non-treatment of the deficits in decision making—leads to an ethically unacceptable consequence, one is confronted with a dilemma: the ethical dilemma of impaired consent.

A non-naturalistic explanation distinguishes the normative from the descriptive level, so a non‐naturalistic concept of informed consent should presuppose the ‘human brain’ as an embedded ‘human black box’. Taken together, the ‘human black box’ as an isolated ‘human black box’ is presupposed to underlie decision making, whereas the ‘human black box’ as an embedded ‘human black box’ must be affiliated with informed consent. If one identifies informed consent with decision making, as in naturalistic explanations, the distinction between the isolated and the embedded ‘human black box’ can no longer be maintained. Although the reasons cannot be discussed here, equating the isolated with the embedded ‘human black box’ is neither empirically nor conceptually plausible. The need for distinguishing between the isolated and the embedded ‘human black box’ in empirical and conceptual ways thus presents a strong argument against a naturalistic concept of informed consent in terms of decision making because then the distinction between both kinds of ‘human black box’ must be resolved. A non‐naturalistic concept of informed consent is thus suggested. Such a concept no longer reduces informed consent to mere decision making and associates it with the embedded rather than with the isolated ‘human black box’.

How can we resolve the ethical dilemma of impaired consent? Conceptually, it could be resolved by distinguishing between the ‘human black box’ of decision making and the ‘human black box’ of informed consent. The ‘human black box’ of decision making is characterised by the descriptive level and isolation from the environmental context; it is an isolated ‘human black box’. In contrast, the ‘human black box’ of informed consent is characterised by both the descriptive and the conceptual levels, with consecutive integration into the respective environmental context; it is an embedded ‘human black box’. If the isolated ‘human black box’ and the embedded ‘human black box’ are distinguished from each other, as in a non‐naturalistic explanation, the organ of therapy is no longer identical to the organ of informed consent. This implies that the ability to give valid informed consent is no longer exclusively tied to decision making. Prior consent to the treatment of deficits in decision making remains no longer impossible and excluded; the ethical dilemma of impaired consent is resolved. Empirically, the ethical dilemma of impaired consent can be resolved by what researchers call a two‐stage therapy of decision making.

This section gives an introductory overview of basic aspects of the emerging field of neuroeconomics, as a contemporary approach to economic theory and practice. In many ways, neuroeconomics can be regarded as a new, multi- and inter-disciplinary orientation to economic thinking that interweaves the current international renewal of the economic sciences, in particular the ‘new experimentalism’, and the most recent technological advances in brain research, ecology and environmentalism. Also, the field integrates aspects of trans-culturalism and socio - Managerial anthropology. Given that recent progress in neuroscience and neurotechnology may profoundly modify globalized human culture (and, perhaps human behaviour, if not identity), neuroeconomics can be considered as an experimental field that is closely related to the most avant-garde developments in the applied sciences. Thus, it has potential to become an important pillar of a broader, and more differentiated post-crisis economic theory that looks beyond neoliberal reductionisms, and is oriented toward multi-dimensionality, integration of different scientific insights, sustainability and an applied, more realistic humanism. In recognition of the bio-psychosocial - Managerial realities of the human being and human interactions, any meaningful attempt at such an approach must include anthropological, environmental and socio-cultural dimensions, so as to assume an appropriately multi-dimensionality, and inter-disciplinarily that aims to experimentally broaden the limits of ‘classical’ and ‘pure’ economic thinking. Consequently, the need to consider how neural substrates and mechanisms contribute to (if not sub serve) decision-making becomes evident; and this has led to the development of the new, interdisciplinary field of neuroeconomics.

Neuroeconomics can be considered to be a growing, but still experimental, pre-normative and descriptive discipline, and a set of practices that engage neuroscientific approaches to assess and inform assumptions about economic decision-making. The field originated in the 1970s when economic models began to merge with ideas from psychology and – at least rudimental – socio - Managerial anthropology, to form behavioural economics. By the end of the 1990s, the obvious limitations, if not frank flaws, of neoclassical economics dictated the development of a more comprehensive approach that could explanation for bio-psychosocial - Managerial variables operative in oftentimes non-rational decisions and actions toward acquiring and distributing limited resources.Currently, neuroeconomics can be considered to be a growing, but still experimental, pre-normative and descriptive discipline, and a set of practices that engage neuroscientific approaches to assess and inform assumptions about economic decision-making.In this way, neuroeconomic analyses may be able to contribute to, and compensate for limitations of neoclassical theory, and may be of current and future value in defining, guiding and perhaps predicting economic activities in the socio - Managerial sphere. Yet, the science is nascent, and the socio - Managerial milieu large; thus we must ask: In which sense? And how, exactly? Rational decision theory remains a fundamental mathematical tool for describing how decisions ought to be made. This approach is based upon a view of human as ‘homo economicus’- a ‘rational, self-interest guided, unemotional utility maximizer’. However, theoretically rational behaviour does not always occur; consequently while humans can be perceived as homo economicus under particular conditions, these certainly are not universal. Assumptions of neoclassical economics do not obtain the irrationality and emotionality of real human actors. In discussing these issues, Kahneman states, ‘…most judgments…and decisions are made intuitively,’and not in a deep, contemplative manner as suggested by Smithian theory. Role of emotions in making judgments and decisions is conspicuously absent in homo economicus approach. This means that neoclassical theory remains lacking when describing actual human behaviour. Hence, conclusions based upon such a theory are often erroneous. This notion is further supported by the fact that emotions are frequently unconscious, yet can strongly influence and direct behaviour. In other words, some judgments based on emotions arising from previous experiences are not able to be rationalized because they are not apparent to the decision-maker. Consequently, a more realistic and integrative model that explanations for biological, psychological, socio - Managerial and cultural aspects of human experience (all of which are partly conscious, and partly unconscious in structure and pattern) has been proposed by Cañadas and Giordano. In this model, biological elements include ‘predispositions, tendencies, and substrates that establish mechanisms and baselines in decision-making’. The psychological element reveals ‘positive and negative neuro-cognitive and emotional responses to both the biological and environmental condition’; and the socio-cultural element entails ‘…effects incurred by factors of the external environment’, including artificial ‘second natural habitat’ of human beings, which is culture.

What is rational decision? Green and Shapiro (1993) treat it as an empirically worthless but nonetheless highly pretentious theory. Shepsle (1995) treats it as the worst social scientific paradigm we have, except for all the rest. And researchers have elsewhere (Cox 1999) reduced it to game theory, called it a methodology, and analogized it to statistics. In this thesis, I consider rational decision both as a paradigm, identifying what researchers view as its ‘hard core,’ and as a methodology, again reducing it to game theory and comparing it to neuroManagerial decision econometrics. One way to locate rational decision theory is in terms of what it assumes about human psychology. Social science does not necessarily need to incorporate a full-blown theory of psychology, just as cell biology does not necessarily need to incorporate a full-blown theory of molecular interaction. However, if one does not need all the complexities that psychologists or cognitive scientists discern, what is the minimum one does need? Radical behaviourism in social science would take the position that one can get by without any theory of psychology at all—and should do so since mental phenomena are inherently (or at least practically) unobservable, hence outside the purview of an empirically based science.[[1]](#footnote-1) Rational decision theory can be viewed as refining what philosophers call ‘folk psychology’ (Ferejohn and Satz 1994b), the root idea of which is that actions are taken in light of beliefs to best satisfy desires. Belief-desire psychology is the implicit model of a vast horde of novels, narrative histories, and journalistic explanations; and the explicit model of many treatises in economic, sociological and political science.[[2]](#footnote-2) What one might call cognitive decision theory is an emerging body of social scientific inquiry in which something more complicated than folk psychology is (formally) assumed about individuals. A good deal of novels, histories and journalistic explanations might stray (informally) into this camp, too. By this explanationing, rational decision can be distinguished from what it is not on two fronts. On the one hand, it is not as squeamish about referring to unobservable mental states as were the radical behaviourists. On the other hand, it confines itself to just two categories of mental phenomena—beliefs and desires—where in principle one might have indefinitely more complicated psychologies than that.

Probability theory and statistics emerged as attempts to improve thinking about correlation and causation. Game theory emerged as an attempt to improve thinking about belief-desire explanations. Statisticians focus on imperfections in causal inference—e.g., those that arise from neglecting selection bias—and seek ways to detect and ameliorate each problem. Game theorists focus on imperfections in belief-desire explanations—e.g., those that arise from relying on incredible threats—and seek ways to purge such reliance from our explanations. As methodologies, statistics and game theory share many similarities. For example, both produce large cookbooks of standard models; both employ various principles for concocting new models; and both feature a division of labor between pure theorists, who study the logical properties of models, and applied theorists, who use models to explain real-world phenomena. Both statistics and game theory also deal with systems of equations, representing multiple causal interactions. In game-theoretic models, each actor’s optimal decision is represented by a separate equation, with their beliefs about each other’s decisions regulated by some equilibrium concept. The result is a system of interrelated decision equations, with sometimes complex interactions and feedbacks. Things are abstractly similar in neuroManagerial decision econometrics. One has a system of equations, each pertaining to a given endogenous variable. These equations are interrelated via (various decisions the analyst makes concerning) cross-equation error correlations and the like.

Sometimes one hears the claim that additional training in neuroManagerial decision econometrics or game theory will push the discipline toward methods-driven, rather than problem-driven, research. If we invest more heavily in quantitative methodologies, so the argument goes, we will increasingly study problems that can be studied with those methods. To some extent, these worries are no doubt well-founded. Presumably those who invest in any given set of tools—say, area studies skills—will then look for problems that can be addressed using those skills. However, one must hope that each individual scholar chooses her research projects wisely, looking both to the problem’s intrinsic importance and the probability that she will be able to contribute to its illumination, given her skills. Sheer importance may even induce some quantitatively skilled researchers to do archival research themselves, or bring area-studies specialists to ‘commit a social science.’ But suppose this happy breadth of view does not arise in individual scholars. Suppose our methodologists remain relatively eclectic in substance and narrowly focused in method, while our non-methodologists remain relatively eclectic in method but narrowly focused in substance. In this case, there is still the possibility that collaboration will restore some breadth and balance of vision, both substantive and methodological. Indeed, one might define modern science as simply the specialization of intellectual labor in order to solve practical and theoretical problems. From this perspective, the suggestion that we must choose between more scientific method-driven and less scientific problem-driven approaches to research is puzzling. Science applies methods to solve problems.

In this thesis, I have suggested that one way to locate rational decision theory is in terms of what it (appears to) assume about human psychology. From this perspective, rational decision can be distinguished from radical behaviourism on one side, and from cognitive decision theory, on the other. Radical behaviourism would rely as little as possible on statements about unobservable mental entities, such as preferences and beliefs. Rational decision theory regularly trots these two entities out. Cognitive decision theory would trot out emotions, moods, and other unobservable mental phenomena as well; and use them all in a consequential way in modeling social interactions. From this perspective, any scholar who is basically satisfied with belief-desire psychology as a shorthand model in analyses that focus on social phenomena could be classified (broadly) as a rational decision theorist. The only ones who would escape this classification would be those who both insist on purging social science of references to unobservable mental phenomena; or who systematically and consequentially bring in an even richer psychology in their theories of social, economic and political interaction. By a narrower, harder definition of rational decision theory, only those scholars who make liberal use of (1) complex errorless deduction from information to beliefs and (2) common knowledge assumptions would qualify. As a classification device, such a definition might have been useful twenty years ago but now it would hardly work to provide any useful sorting even of game theorists, much less any larger community of scholars. Nonetheless, the definition is useful in identifying the part of rational decision analysis that has attracted the most criticism: the theory’s assumptions and modeling of beliefs. Viewed as a methodology, rational decision analysis (in the guise of game theory) deals with systems of (decision) equations and uses equilibrium concepts (which include stipulations of what is common knowledge) and information-to-beliefs assumptions (e.g., Bayesian updating) in more or less the way that econometricians use cross-equation error assumptions (e.g., independence) or exclusion restrictions. Such assumptions help to pin down the causal pathway. In both disciplines, assumptions used to tame multi-equation systems need to be justified on substantive grounds, when employed in specific empirical investigations. Debates of whether or not there is sufficient justification should, in principle, proceed on a model-by-model basis. Universal debates of pathologies afflicting all of neuroManagerial decision econometrics or all of game theory seem unlikely to produce methodological or substantive advance, relative to specific diagnoses of what is wrong with the current models and what might be done to improve or replace them.

NeuroManagerial neuroeconomic decision making is one of the most discussed developments in socio - Managerial science at present. Alongside behavioural Managerial neuroeconomic decision makings, neuroManagerial neuroeconomic decision makings promise to introduce a crucial experimental element into the mostly observational methodological tool-box of Managerial neuroeconomic decision makings. The unavailability of experimental control of key Managerial neuroeconomic decision making variables has been seen as one of the main obstacles for reliable causal reasoning. Direct experimental investigation of the neural mechanisms underpinning Managerial neuroeconomic decision making behaviour is hoped to remedy this situation.

Overall, this multi-dimensional and thus potentially integrative approach combines neuro-biological, socio - Managerial and trans-cultural dimensions of decision-making and trust into a ‘stratified image’ of the human being and its behaviour(s). Important to this paradigm is the need to characterize the interaction of physical, psychological, cultural, and even spiritual cognitions that establish various decisions, and which relate decisional-actions and outcomes to evaluations of trust. We opine that this explicitly experimental (heuristic) neuro-bio-psycho-socio - Managerial model of trust encompasses at least six dimensions:

* A neural level that proposes the neural networks involved in ecological / economic decision-making;
* A biological attribute that describes the evolutionary and developmental bases and relevance of decision-making and trust;
* An anthropological component that defines and describes the collective meaning and basic value of trust for human beings as a self-conscious species among other (conscious) species;
* A psychological aspect that provides a definition of trust pertinent to the specific cognitions, emotions and character of an individual;
* A philosophical dimension that regards the rational dimension of trust in the sense of an in-depth scrutiny of causes and origins as related to effects;
* A socio - Managerial level of influence, that describes dependent inter-relations with others, respective past and present experiences of these inter-relations;

But why would specifically neurological experiments be relevant to causal knowledge concerning the Managerial neuroeconomic decision making realm? Practitioners and philosophers have advanced a number of arguments. First, neuroManagerial neuroeconomic decision makings holds out the promise to unify within the socio - Managerial sciences: uncovering the neural underpinnings of decision making would get us a theory that is applicable to all human behaviour in all socio - Managerial contexts. We could use the same theory to causally explanation for, not just rationalize post hoc, pro-socio - Managerial behaviour as well as for self-regarding Managerial neuroeconomic decision making decisions. Second, neuroManagerial neuroeconomic decision makings evidence has been thought to establish the reality of key Managerial neuroeconomic decision making variables; for example, some measurable neural phenomenon of decision (activation patterns in VTMPFC) is said to be the physiological referent of utility, thus vindicating a realist interpretation of Managerial neuroeconomic decision making theory. Similarly activation of anterior insula and the effects of administration of oxytocin on behaviour in games are taken to establish the reality of socio - Managerial preferences. Third, neuroManagerial neuroeconomic decision makings has been claimed to improve on Managerial neuroeconomic decision making explanations by providing the mechanistic details behind decision-making. Whereas existing models of decision making are behavioural or based on poorly understood psychological constructs, neuroManagerial neuroeconomic decision makings provides hard mechanistic details, which, so the argument goes, automatically improve Managerial neuroeconomic decision making explanations. Direct causal control of these mechanistic variables can be seen as a more reliable form of causal inference than observational inference from behaviour, which even in an experimental setting has to rely on the assumption that the subject’s model matches the experimenter’s model.

In this paper we show that neuroManagerial neuroeconomic decision makings do none of these things. First, it does little to unify socio - Managerial phenomena because knowledge of neurological mechanisms of decision-making is not explanatorily relevant for all or even most socio - Managerial scientific phenomena. Moreover, unification as such cannot be used as an evidential argument for the probable truth of neuroManagerial neuroeconomic decision making hypotheses. Second, that neuroManagerial neuroeconomic decision makings provides ‘the mark of the real’ for typical socio - Managerial scientific explanation rests on the mistaken intuition that causal relations are more real the closer we get to describing them in a purely physical vocabulary. Without this assumption, the finding that there is a correspondence between a psychological entity and a particular brain area does not, by itself, make the psychological entity any more real. Third, neuroManagerial neuroeconomic decision makings do not automatically improve Managerial neuroeconomic decision making explanations, because mechanistic details are not always explanatorily relevant for socio - Managerial and Managerial neuroeconomic decision making phenomena. Mechanistic details only improve the explanation of the original socio - Managerial scientific explanandum if knowledge of them effectively increases our ability to make causal and explanatory inferences about the explanandum. Thus far, however, this has rarely been the case in neuroManagerial neuroeconomic decision makings. Consequently, just the fact that some neural variables are directly manipulated does not necessarily mean that Managerial neuroeconomic decision making relevant variables are been controlled. Moreover, the argument that unlike behavioural experiments, neuroManagerial neuroeconomic decision makings experiments obviate the need for matching the subject’s and the experimenter’s models, and hence afford more reliable causal inferences, overestimates the current status of neurological theories of decision making.

We argue that the relevance of neuroscientific findings is mostly to be understood in terms of triangulation of evidence by independent means of determination. Triangulation is a standard term in the methodology of the socio - Managerial sciences. It refers to the use of multiple different and independent sources of evidence or theoretical perspectives to check whether a putative phenomenon is an artifact of some particular method or perspective. The epistemic rationale of triangulation is thus to distinguish the real from the artefactual by controlling for errors and biases of particular methods. Conceiving neuroManagerial neuroeconomic decision making experimentation as triangulation explicates what is correct behind some of the arguments discussed above. For example, a finding that a certain brain area is involved in altruistic punishment does not, as such, render socio - Managerial preferences more real by providing a physical realiser, but provides additional confirmatory evidence through another independent means of determination (i.e. imaging studies of the brain or the measurement of hormonal levels in the body) of the involvement of socio - Managerial preferences in the explanation of altruistic punishment. A similar point applies to unification: when appraising neuroManagerial neuroeconomic decision making hypotheses, the sound evidential principle of triangulation should be distinguished from the common intuition that neuroManagerial neuroeconomic decision making hypotheses are likelier to be true in virtue of explaining much by little. The latter mixes evidential and explanatory virtues. Unification in this case is relevant only insofar as a unifying hypothesis related to diverse sources of evidence actually has more, and mutually independent, evidence. Our claims apply beyond the case of neuroManagerial neuroeconomic decision makings: the epistemic contribution of neuroscience to socio - Managerial scientific theories and explanations lies in the generation of (further kinds of) evidence for the triangulation of socio - Managerial scientific hypotheses.

Traditionally, object of economic theory and experimental psychology, economic decision recently became a lively research focus in systems neuroscience. Traditional Managerial decision economic theory assumes that human beings behave rationally. That is, that they understand their own preferences, make perfectly consistent decisions over time, and try to maximize own well-being. This peculiar assumption has its roots in publications like Exposition of a New Theory on Measurement of Risk by Daniel Bernoulli (1738) and Theory of Games and Economic Behaviour’ by John von Neumann and Oskar Morgenstern (1944). The idea has some validity: traditional economic theory is good at predicting some behaviours, but it's not very good at describing more-complex phenomena. The problem, of course, is that Managers don't always behave rationally. They make decisions based on apprehension, greed and envy. They indulge in risky behaviour such as gambling. Economists understand this as well as anyone, but in order to keep their mathematical models tractable, they make simplifying assumptions. Then they try to adjust their equations by adding terms that explanation for ‘irrational’ behaviour.

The irrationality of human decision-making attracts the fierce interest of two very different fields: neuroscience and economics. Economic theories of human decision-making are essentially based on two parameters: what something is worth and the probability of its occurrence. Neuroscientists, on the other hand, think of decision-making as a product of physical neural circuits: sensory information enters the brain, journeys through the brain where a decision is ‘made,’ and eventually exits the brain to evoke bodily responses. Economics ignores these biological, more proximal roots of behaviour, whereas neuroscience ignores the economic goals that ultimately guide our decisions. These two approaches have recently been integrated in the hybrid field of Managerial neuroeconomic decision making. Managerial neuroeconomic decision making attempts to unify abstract economic variables with neuroanatomy, and thus understand physical mechanisms by which our brains make decisions. The basic premise is that somewhere along sensory-motor circuits are the neural substrates that represent ‘value’ and ‘probability.’ These areas must interact and influence flow of information along the circuit, thereby prompting a certain decision and its subsequent behaviour. Pressing questions, then, are how and where these abstract variables are combined in the brain, and the dynamics of the neural computation which engenders a ‘decision.’ Because economists base their models on optimal behaviour, they have the ability to develop a precise, unified framework for interpreting human behaviour; thesis is, essentially, that humans choose alternatives that maximize rewards. Managerial neuroeconomic decision making draws upon the precision and rigor of formal models of economics to go beyond the sensory-motor circuit, allowing opportunities for understanding neural basis of more abstract economic ideas, such as value and the profitability of outcomes (a bit more challenging to study than sensory and motor systems). Thus, principle of economics allows neuroscientists to explore physical mechanisms underlying high level cognitive processes.

But if Managerial decision Economists could develop models that explain for subtleties of human brain, they might be able to predict complex behaviours more accurately. This, in turn, might have any number of practical applications: investment bankers could hedge against financial euphoria like Internet boom; advertisers could sell products more winningly. The idea that understanding the brain can inform Managerial decision Economics is controversial but not new; for 20 years, behavioural economists have argued that psychology should have a greater influence on the development of economic models. What is new is use of technology: economists, like other researchers, now have at their disposal powerful tools for observing brain at work. functional Magnetic Resonance Imaging (fMRI) has been around since late 1980s; but only in past few years has it been used to study decision-making, which is crux of economic theory. The result is emerging field of ‘neuroManagerial decision Economics.’ A flurry of recent papers in scientific and economic by Caltech Managerial decision Economics Professor Colin Camerer shows how researchers are using neural basis of decision-making to develop new neuroManagerial decision economic models.

Neuroeconomic decision making has always relied on a careful modelling of decision-makers. They are described by utility functions that represent their goals, and they interact at (Nash) balance. Nevertheless, discrepancies between theoretical predictions and observed behaviour have haunted the field for many decades. The objective of neuroeconomic theory is to build models based on evidence from brain sciences, such as experimental neuroeconomic decision making, but also other fields in neuroscience and neurobiology. Measurement of brain activity provides information about the underlying mechanisms used by the brain during decision processes. In particular, it shows which brain regions are activated when a decision is made and how these regions interact with each other. This information can then be used to build a model that represents this particular mechanism. Contrary to behavioural neuroeconomic decision making, the model does not rely on introspection or plausible assumptions but rather on an existing and documented biological property of the brain. Deciphering brain - environment transactions requires mechanistic understandings of neurobiological processes that implement value-dependent decision-making. There is a crucial difference between ‘thinking about thinking’ and actually enhancing brain and mental processes by developing latent potential of each individual. Theoretical explanations posit that human brain accomplishes this through a series of neural computations, in which expected future reward of different decision options are compared with one another and then option with highest expected value is selected. If human brain is often compared with computer, one aspect is crucially missing. Humans define goals for information processing in computers, whereas goals for biological brains are determined by need for survival in uncertain and competitive environments. How to handle brains behind businesses in age of dramatic alter and growing uncertainty? What then are the coherent brain dynamics underlying prediction, control and decision-making? To cope with this mismatch, behavioural economists have developed new theories of decision-making that are a better fit for the behavioural data than traditional models. The methodology consists in building models to demonstrate the relationship between cause (preference for particular object) and behavioural anomaly. This line of research formulates possible explanations for behavioural data, but it is nevertheless subject to shortcomings. Often the cause is not observable, and there is no evidence of the relationship provided by the model. Most notably, freedom provided by introspection method leads to model selection problem. Also, cause of behavioural anomaly may simply lie elsewhere.

The methodology used in neuroeconomic theory has two advantages. Primarily, evidence from the brain sciences provides precise guidelines for the constraints that should be imposed on decision-making processes. This can help uncover the ‘true’ motivations for the ‘wrong’ decisions and improve the predictive power of the theory. Behavioural theories that explanation for biases in judgment build on specific models of preferences over beliefs or non-Bayesian updating processes. Rather than guessing a cause for biases, neuroeconomic theory builds a model based on the existing physiological properties underlying learning and belief formation. In principle, this can help pinpoint biological foundations for anomalous decisions. For example, research in neurobiology demonstrates that the brain cannot encode all the information contained in a signal. A decision is triggered when ‘enough’ information supporting one alternative is obtained, and the brain uses a variety of biological mechanisms to filter information in a constrained optimal way. In a recent paper we show that these properties of the brain result in a behavioural tendency to confirm initial priors (Brocas and Carrillo; 2009). Behavioural data reports precisely that individuals stick too often to first impressions. These confirmatory biases may all emerge from the same set of physiological information processing constraints. Further work in that direction may help uncover the causes of other biases and determine whether they are all related to the same physiological limitations. The second advantage is that by explicitly modelling physiological properties, it is possible to provide foundations for some elements of preferences traditionally considered exogenous, such as risk aversion, ambiguity aversion, or time-preference rates. Decisions involving risk, uncertainty, or time delays may require complex trade-offs. Measures of brain activity allow us to determine if the evaluation process is centralised or if different brain systems compete to influence the final decision. Neuroeconomic theory proposes to model the actual brain organisation, determine the behaviour that emerges from it, and evaluate which theory fits best.

One example is ‘discounting’. The standard neoclassical theory derives time-preference rates from a set of axioms on the preferences of individuals. A nice property of these axioms is that discounting must be represented by a time-consistent function. To explanation for the observed tendency of individuals to procrastinate, behavioural economists have modified this function by introducing a parameter of time-inconsistency whereas decision theorists have modified the original axioms. In both cases, the motivation for the new theories is a behavioural observation that cannot be reconciled with the original theory. Instead, our recent research uses neurobiological evidence to model inter-temporal decisions as the result of a conflict between two brain systems, one interested in immediate gratification and one that can form a mental representation of future rewards. Using this approach we are able to derive from first principles three properties of dynamic decisions commonly observed in the data: positive discount rate, decreasing impatience, and heterogeneity of discount rates across activities (Brocas; 2008). A similar methodology can be applied to rationalise other observed characteristics of preferences.

Experimental neuroeconomic decision making is controversial. While some consider it to be an irrelevant body of research, there are those who claim it is essential (Camerer; 2005 and Pesenderfor; 2008). In fairness, the field is probably too young to tell. Surprisingly, the debate has been centered on empirical issues regarding the collection method, amount, cost, and quality of brain data – the broad implications have not received as much attention. Indeed, the new set of data provided by experimental neuroeconomic decision making will shed light on the causes of behaviour (and consequently of the behavioural anomalies) and help build new theories capable of explaining and predicting decisions, a long-term goal of neuroeconomic decision making. Neuroeconomic theory offers to do precisely this. So far, research in that direction has been very limited and its impact has been largely ignored. Neuroeconomics offers a solution through an additional set of data obtained via a series of measurements of brain activity at the time of decisions. Experimental neuroeconomics can be seen as a subfield of experimental neuroeconomics, where behavioural data is enriched with brain data. Neuroeconomic theory proposes to build brain-based models capable of predicting observed behaviour.

**Neuroeconomic Managerial decision Traps**: Review by Thanh Pham in Neuroeconomic Managerial decision Traps indicate that most neuroeconomic Managerial decision makers commit some kinds of errors and explore components of those errors and steps to rectify those common mistakes in neuroeconomic Managerial decisions making. The author indicates that becoming a good neuroeconomic Managerial decision maker is to examine process of neuroeconomic Managerial decision-making systematically and need to work consistently to eliminate errors. Every good neuroeconomic Managerial decision-maker must, consciously or unconsciously, go through each phase of neuroeconomic Managerial decisions making process. The ten most common barriers often encountered in making good neuroeconomic Managerial decisions are: 1) Plunging in - Here, we beginning to gather information and reach conclusion without first taking a few minutes to think about the crux of issue you’re facing or to think through how we believe neuroeconomic Managerial decisions like this one should be made. 2) Frame blindness - Setting out to solve the wrong problem because we have created a mental framework for your neuroeconomic Managerial decision, with little thought, that causes you to overlook the best options or lose sight of important objectives. 3) Lack of Frame control - Failing to consciously define the problem in more ways than one or being unduly influenced by others. 4) Overconfidence in our Judgment - Failing to collect key factual information because we are too sure of our assumptions and opinions. 5) Shortsighted Shortcuts - Relying in appropriately on ‘rules of thumb’ such as implicitly trusting the most readily available information or anchoring too much on convenient facts. 6) Shooting from the Hip - Believing we can kept straight in our heads all the information you are discovered, and consequently ‘winging it’ rather than following a systematic procedure when making the final decision. 7) Group Failure - Assuming that with many smart Manager involved, good decisions will follow automatically and consequently failing to manage the group neuroeconomic Managerial decision-making process. 8) Fooling Ourselves About Feedback - Failing to interpret the evidence from past outcomes for what it really says, either because we are protecting our ego or because we are tricked by hindsight. 9) Not Keeping Track - Assuming that experience will make its lessons available automatically, and consequently failing to keep systematic records to track the results of your neuroeconomic Managerial decisions and failing to analyse these results in ways that reveal their key lessons. 10) Failure to Audit our Neuroeconomic Managerial decision Process - Failing to create an organised approach to understanding our own neuroeconomic Managerial decision making, so we remain constantly exposed to the entire above mistake. The author indicates that good neuroeconomic Managerial decisions making can be broken into four main elements and they are as follows: 1) Framing - Structuring the Question, this means defining what must be decided and determining in preliminary way what criteria would cause us to prefer one option to another. 2) Gather Intelligence - Seeking both the knowable facts and reasonable estimates of ‘unknowable’ that we will need to make the neuroeconomic Managerial decision. 3) Coming to Conclusion - Sound framing and good intelligence do not guarantee a wise neuroeconomic Managerial decision. Managers are simply unable to consistently make good neuroeconomic Managerial decisions using seat-of-the-pants judgment alone, even with excellent data in front of us. 4) Learning from Feedback - Everyone needs to establish a system for learning from the results of past neuroeconomic Managerial decisions. This usually means keeping track of what we expected would happen, systematically guarding against self-serving explanations, than making sure we review the lessons our feedback has produced the next time a similar neuroeconomic Managerial decision comes along. The author also reviews each barrier and recommended steps necessary to address them. Addressing the first barrier, the author indicates a wise and timely meta neuroeconomic Managerial decision base on four key elements above can help to avoid the neuroeconomic Managerial decision trap one Plunging in when we start working on any major issue. We should spend time to think about the large issues we are facing. A Meta neuroeconomic Managerial decision involves asking questions like ‘what is the crux of this issue? In general, how do I believe neuroeconomic Managerial decisions like this one should be made? How much time should I spend on each phase-as the first guess?’ So before any major neuroeconomic Managerial decision process is launched, review the Meta neuroeconomic Managerial decision questions. To address the second barrier, the author indicates that from the greatest genius to the most ordinary clerks, we have to adopt mental frameworks that simplify and structure the information facing us. But often than not, Manager simplify in ways that force them to make the wrong decisions and get into the neuroeconomic Managerial decision trap number two frame Blindness. Consequently to avoid it, we should attempt to understanding frames. No frame, indeed any way of thinking, can consider all possibilities and no one can completely avoid the dangers of framing. However, we would pay dearly if we do not even know the problem exists. Here, the author’ correlation of a window frame nicely illustrates the difficulties. Architects choose where to put windows to give a desired view. But no single window can reveal the entire panorama. When we choose which window to look through, or even if we decide to keep track of what’s happening through three different windows, we can never be sure in advance that you will get the most useful picture. Thus, framing of a neuroeconomic Managerial decision inevitably sets boundaries; it controls what is in and what is out. Moreover, not all elements that are ‘in’ will be treated equally. Our frames tend to focus us on certain things while leaving others obscured. Frames have enormous power. The way Manager frame a problem greatly influences the solution they will ultimately choose. Also, the frames that Manager or organisations routinely use for their problems control how they react to almost everything they encounter. Consequently, when we face a new issue, good neuroeconomic Managerial decision-maker create a neuroeconomic Managerial decision frame specifically designed for dealing with that problem. Neuroeconomic Managerial decisions makers fall into the neuroeconomic Managerial decision trap number three, Lack of Frame control because we often do not choose frames. We stumble into them and found ourselves using inadequate frame. Consequently, if we match our own frame to the frames of Manager influence us, we can improve our performance significantly by: 1) Know Your Own Frames - we need to know how we have simplified our problems 2) Know The Frames Of Others - if we know others frame problems, we can tailor our communication to them. 3) Open Minded Framing - when we approach a new issue, try to remain open minded about the frame. Two neuroeconomic Managerial decision traps common to most of us is Overconfidence in our judgment and Shortsighted shortcuts. These dangers can cause problems throughout the neuroeconomic Managerial decision making process, but they particularly affect the gathering of information and intelligence. Wise neuroeconomic Managerial decision makers avoid them and work to assure high quality intelligence. Many Manager suffer from overconfidence in what they believe even if their belief entails a negative view of their own worth and abilities. To address this, the author indicates that we should sizing up what we know - That is, collecting information and using it systematically will reduce the dangers from overconfidence, availability bias, and anchoring. The author also indicates that overconfidence is related to another problem called Confirm bias, where Manager's fondness for evidence that will confirm, rather than challenge, their current beliefs. Avoiding overconfidence means developing good secondary knowledge where primary knowledge consists of facts and principles we believe are true. In additional to overconfidence, we must also watch out for neuroeconomic Managerial decisions making shortcuts. Misleading shortcuts give Manager false intelligence, and can derail the entire neuroeconomic Managerial decision process. Shooting from the hip barrier is when we rely on institution to make a neuroeconomic Managerial decision, our mind processes part or all of the information you possesses automatically, quickly and without awareness of any details. But it seldom takes proper explanation of all the information available. The author believes that initiative neuroeconomic Managerial decisions are affected not only by the evidence that should affect our decision, but also by factors such as fatigue, boredom, distractions and recollection of a fight with your spouse at breakfast. But on other hand, initiative neuroeconomic Managerial decisions making does have at least one advantage. It takes less time than making a neuroeconomic Managerial decision with systematic methods. However, disadvantages of intuitive neuroeconomic Managerial decisions making are more profound than most use realize. Manager who make neuroeconomic Managerial decision intuitively achieve much less consistency than they generally suspect. The author indicates that to maximize chances of making best decision if we find a systematic way to evaluate all evidence favourable to each possible decision, compare the strength of evidence on each side rigorously, then pick the decision that system indicates evidence favours. Here, neuroeconomic Managerial decision theorists call this kind of decision system a subjective linear model. It is subjective because the importance assigned to each pro and con from human being's head, not from direct calculations based on the real world. Group Failure barrier, here groups of smart, well-motivated Manager are mismanaged. Members agree prematurely on the wrong solution. Then they give each other feedback that makes the group as a whole feel certain that it is making the right decision. Members discourage each other from looking at the flaws in their thought process. The groups may become polarized, with members shifting unreasonably to more extreme position or clinging to opposite sides of an issue. Consequently, progresses toward a rational neuroeconomic Managerial decision become impossible. Through researches, the author believe that groups can make better neuroeconomic Managerial decisions than individuals, but only if they are helped along by a skillful leader. There is little excuse for using costly group meetings to make inferior neuroeconomic Managerial decisions. The author indicates that to make better group neuroeconomic Managerial decisions we should do as following: 1) Intelligent, well-motivated Manager make superior neuroeconomic Managerial decisions in groups only if they are managed with skill. 2) The heart of good group management is encouraging the right kind of conflict within the group, and resolving it fully and fairly through further debate and intelligence gathering. 3) Leaders must decide where in the four elements of a neuroeconomic Managerial decision (framing, intelligent-gathering, coming to conclusions and learning from past cases) the group can make its greatest contributions. 4) Leader should rarely state their own opinions early in group's deliberations, because many group members will fear to offer their own ideas if they contradict the leader's. 5) Generally, leaders should encourage disagreement in early stages of any group process. Then as more facts and insights are gained, the leaders should guide the group toward convergence on a final decision. 6) If a neuroeconomic Managerial decision process really deadlocks, you can often narrow the gap by separating factual issues from value issues. The author indicates that we fall into neuroeconomic Managerial decision trap number 8, Fooling yourself About feedback, because our natural biases make learning much more difficult than we realize. When events come out well, we tend to see the success as a result of our own genius. But when events turn out badly, we rationalize an explanation that preserves our positive self-image. In addition to these biases produced by our desires, we suffer from hindsight effects caused largely by the way our minds work. Consequently, attempting to understand our biases, and can interpret feedback realistically, we can consistently turn our experiences into reliable knowledge. The author also indicates that learning from experience is not automatic. Experience, after all, provides only data, not knowledge. It offers the raw ingredients for learning and we can turn it into knowledge only when they know how to evaluate the data for what they really say. They suggested that Manager often do not learn as easily from experience as you might expect, even intelligent, highly motivated Manager. When making a decision between two or more options, one may not always know the odds of a favourable outcome. Decision-making under ambiguity and under explicit risk are two examples of decision-making without knowledge of the outcome. The author indicates that most Manager’s experience is afflicted with neuroeconomic Managerial decision trap number 9 - Not keeping track by: 1) Missing feedback - lack of information on the key question 2) Entwined feedback - evidence is effected by actions taken by the neuroeconomic Managerial decision maker and associates after making the initial judgment, these factors are called treatment effects 3) Confuse feedback - uncontrollable, unpredictable factors, ‘random noise’ that affect neuroeconomic Managerial decision outcomes; 4) Ignore feedback - incomplete use of information on outcomes they already possess Learning from experience is especially difficult when you face an uncooperative environment like missing feedback or ambiguity due to random noise or treatment effects. To improve with experience, consequently, we need to: 1) Regularly analyse what you are learned recently and how you could be learn more 2) Conduct experiments to obtain feedback you could get in no other way and 3) Learn not just from the outcomes of past neuroeconomic Managerial decisions but also by studying the processes that produced them. The 10th neuroeconomic Managerial decision trap is Failure to audit your neuroeconomic Managerial decision process. Here, we should analyse your own neuroeconomic Managerial decisions making and identify a few key steps we ought to take to improve our neuroeconomic Managerial decisions. Once we are located the few crucial errors, we will find that our neuroeconomic Managerial decisions making can be improved much easily. Often than not, the author indicates that this is the most neglected or misunderstood barrier of the ten neuroeconomic Managerial decision traps.

Economics have always relied on a careful modeling of decision modeling. To cope with this mismatch, economists have developed theories of decision-making that are a better fit for neuro data than traditional models. Methodology consists in building models to demonstrate relationship between cause and neuro anomaly. Freedom offerd by introspection method leads to a model selection problem. Neuro - management decision-making can be regarded as a mental process (cognitive process) resulting in selection of a course of action among several alternative scenarios. Every decision-making process produces a decision. Process must be regarded as a continuous process integrated in interaction with environment. Analysis is concerned with logic of decision-making, rationality and invariant decision making it leads to. This reflects more than compensatory interaction of decision making-related regions. Specific brain systems potentiate decision-makings depending on strategies, traits and context. Consequently, decision making is a reasoning or emotional process which can be rational or irrational, based on explicit assumptions or tacit assumptions. This leads to formulation of a ‘neuro - management decision making paradox’.  Neuromanagement has bridged management and psychology. It challenges standard management assumption that decision-making is a unitary process-a simple matter of integrated and coherent utility maximization. The goal is a mathematical theory of how brain implements decisions that is tied to behaviour. This theory is likely to show some decisions for which rational - decision making is a good approximation (particularly for evolutionarily sculpted or highly learned  decision makings), offer deeper level of distinction among competing alternatives and offer empirical inspiration to incorporate nuanced ideas about endogeneity of preferences, individual difference, emotions and endogenous regulation. Researches investigate central parameters viz. neural bases of decision predictability and value in theory of expected utility.

Decision usually involves three steps: recognition of a need, dissatisfaction within oneself (void or need), decision to alter (fill void or need) and conscious dedication to implement the decision. How are decisions carried out in brain? Do we interpret research findings when neurological results conflict with self-report? What are the general implications of neuro management? Any scientific conceit of objective science preceding mere philosophical speculation must clearly be dismissed as untenable. The narration of science is replete with examples of metaphysical speculation (priors, in contemporary Bayesian) prior, and indeed guiding, scientific confirmation (for instance, speculations about the atomic composition of matter). More importantly than listing historical examples, it could not be otherwise, for as Alfred North Whitehead put it, ‘induction presupposes metaphysics;’ that is, one cannot make any inferences about a system absent speculation of how that system operates. Central argument is that decision-making is at core of all Managerial functions and future of any organisation lies on vital decisions made. Nonetheless, there are certain critical issues coupled with factors such as uncertainties, multiple objectives, interactive complexity and anxiety make decision-making process difficult. At times when making a decision is complex or there are many interests at stake, then we realize the need for strategic decision-making. Hegel cautioned: ‘Unfortunately there soon creeps in the misconception of already knowing before you know.’ In other words, how do we decide on the forms of thought with which to represent the world, before we have observed the world through those forms? What is notable and important about Hegel is his refusal to rest his philosophy on axioms.

Questions include; how to choose in tough situations where stakes are high and there are multiple conflicting objectives? How should we plan? How can we deal with risks and uncertainties involved in a decision? How can we create options that are better than ones originally available? How can we become better decision makers? What resources will be invested in Managerial neuro - economic decision - making? What are the potential responses to a particular problem or opportunity? Who will make this decision? Every prospective action has strengths and weaknesses; how should they be evaluated? How will they decide? Which of the things that could happen would happen? How can we ensure decision will be carried out? These questions are crucial for understanding complex human behaviours.

Few aspects of human cognition are more personal than the decisions we make. Human cognitions and actions are based upon and predicated by beliefs – including a belief in the capacity for, and solidity of reason. However, reasoning as an individual and group process may often advance biases that can both initiate and be used to justify depriving resources form, and/or more overt forms of aggression against those who do not share – or are the object of – particular biases. Such insight to the ways that humans perceive, recall and relate to environmental experiences and interactions, establish expectations, and generate notions of good and bad, and right and wrong, all influence decision-making, will be decisive for the future of neuroeconomics, as a discipline, and economics as a set of activities and practices. More specifically, this approach to understanding the neurobio-psychosocio - Managerial basis of human interaction (with environments, resources and species) is an important focus of neuroethics – at least in its so-called ‘first-tradition’ – what we have referred to as ‘neuro-ecology. Our decisions - from the mundane to the impossibly complex - continually shape the courses of our lives. Neuroeconomic decision making is an interdisciplinary research program with the goal of building a biological model of decision making in economic environments. Neuroeconomists ask, how does the embodied brain enable the mind (or groups of minds) to make economic decisions? Economic decision entails comparing options that vary on multiple dimensions. Hence, while choosing, individuals integrate different determinants into a subjective value. Values of different goods are computed independently of one another, which imply transitivity. Values are not learned as such, but rather computed at the time of decision. Most importantly, values are compared within the space of goods, independent of the sensorimotor contingencies of decision. Decisions are then made by comparing values.

By combining techniques from cognitive neuroscience and experimental Economics we can now watch neural activity in real time, observe how this activity depends on the economic environment, and test hypotheses about how the emergent mind makes economic decisions. Neuroeconomic decision making allows us to better understand both the wide range of heterogeneity in human behaviour, and the role of institutions as ordered extensions of our minds. The brain is the most amazing complex organ in known universe. The brain is an organ with most amazingly magic infinite potential. Neuroplasticity; transforming the Mind by Changing refers to structural and functional alters in the brain that are brought about by training and experience. The brain is the organ that is designed to alter in response to experience. The decision theories can be categorized into three paradigms: the normative, descriptive and prescriptive theories. The decision processing have four steps: accumulation of sensory evidence, integration of sensory signals with reward expectation and prior knowledge, comparison of current reward expectation with that in prior experience and the selection of behavioural response.

In recent years, researchers have applied the tools of neuroscience to understand the mechanisms that underlie decision making, as part of the new discipline of decision neuroscience. A primary goal of this emerging field has been to spot the processes that underlie specific decision variables, including the value of rewards, the uncertainty associated with particular outcomes, and the consequences of socio - Managerial interactions. Recent work suggests potential neural substrates that integrate these variables, potentially reflecting a common neural currency for value, to facilitate value comparisons. Despite the successes of decision neuroscience research for elucidating brain mechanisms, significant challenges remain. These include building new conceptual frameworks for decision making, integrating research findings across disparate techniques and species, and extending results from neuroscience to shape economic theory. To overcome these challenges, future research will likely focus on interpersonal variability in decision making, with the eventual goal of creating biologically plausible models for individual decision.

Neurodecision Economics is a new scientific field which has emerged recently from a joint research program between Managerial decision economists involved in decision-making analysis and neuroscientists interested by the brain activity in the course of goal oriented actions. Psychologists, including behavioural decision making researchers, have conventionally relied on hypothetical constructs for developing theories to explanation for dissimilar phenomena. While management decision making research continues to be vibrant and in exceptional shape, researchers have proposed that the next phase of exciting research is likely to emerge from building on recent advances in neuromanagement decision. Neuromanagement decision can help by providing confirmatory evidence about existence of a phenomenon, generating fundamental (neural-level) conceptualization and understanding of underlying processes, refining accessible conceptualisations of various phenomena, and providing methodologies for experimenting new as well as existing theories. This keenness for integrating neuromanagement decision and management decision making has partly been due to the exponential accretion of knowledge about brain structures and neurological mechanisms since 1990 and partly due to the increased availability of neuroscientific methods to explore various management decision making phenomena. This Chapter presents an introduction to and analysis of an emerging area of research, namely management decision neuromanagement decision, whose goal is to integrate research in neuromanagement decision and behavioural management decision-making.

Contemporary economic theory assumes that human decision-making involves rational maximization of expected utility, as if humans were equipped with unlimited knowledge, time and information-processing power. Decisions are an inevitable part of human activities. Each day life is full of decisions and decisions. An important question is how Managers make (absence) decisions. Specifically, researchers are interested in assumptions, beliefs, habits, and tactics that Managers use to make decisions. Research suggests that brain considers various sources of information before making a decision. Nonetheless, how does it do this? In addition, why does the process sometimes go awry, causing us to make impulsive, indecisive and confused decisions; kinds that can lead to risky and potentially dangerous behaviours? Human behaviour is not the product of a single process. To a certain degree it reflects interaction of different specialized subsystems. These systems usually interact seamlessly to determine behaviour, but at times, they compete. Effect is that brain sometimes argues with itself, as these distinct systems come to different conclusions about what we should do. Human behaviour, in general, is not under constant and detailed control of careful and accurate hedonic computations. It is product of an unstable and irrational complex of reflex actions, impulses, instincts, habits, customs, fashion and hysteria. For a long time, economists have argued that humans make decisions by obeying laws of rationality. Human behaviour is inherently multi-modal. Human performance has been subject of active research from quite a few perspectives. How do we make a decision? Decision makers have tendency to seek more information than required to make good decision. When too much information is sought and obtained, one or more of several problems can arise. A delay occurs because of time required to obtain and process extra information. This delay impairs effectiveness of decision or solution. Information overload occurs. In this state, decision-making ability actually declines because information in its entirety can no longer be managed or assessed appropriately. A key problem caused is forgetfulness. When too much information is taken into memory, especially in a short period, some information (often that received early on) will be pushed out. Neuroabsenteeism seeks to give explanation human decision-making, ability to process multiple alternatives and choose an optimal course of action. It studies how absence behaviour shape understanding of brain and guide models of absence via. Neuro-Economics, Experimental and Neuroabsence and Cognitive and Psychology.

What are models and how can we use them to establish or investigate causal relations? Are natures of models same or different across scientific domains? What are the relevant distinctions connecting different modelling practices? How should we regard formal techniques for quantitative representation of causal relations, and for data mining? Can purely predictive models be useful in investigating causal systems? What good are models for pedagogical purposes? How should we trade off close relationship to the target system with increasing idealization and sophistication of the model? From a philosophical point of view, what are the assumptions and implications of the use of the representative agent as it is developed in the frame of some Managerial decision economic models?

Both economists and personality psychologists seek to identify determinants of heterogeneity in behaviour. Economists typically depict decision problems in a framework of utility maximization. An individual's utility is shaped by preferences such as risk, time, and social preferences. These preferences, in combination with expectations of future events, perceptions, beliefs, strategic consideration, prices and constraints shape behaviour. An integration of the different measures and concepts used by economists and personality psychologists promises much potential for amalgamating evidence about the drivers of human behaviour which accumulated disjointedly in the fields of economics and psychology (Borghans et al., 2008). Recently, scholars have begun to integrate personality into economic decision making (e.g., Borghans ; 2008). Almlund ;2011) enrich theory by incorporating personality traits in a standard economic framework of production, decision, and information. Their model interprets measured personality as a \construct derived from an economic model of preferences, constraints, and information’ (Almlund et al., 2011, p.3). However, empirical knowledge is too limited to judge how personality traits relate to the concepts and parameters economists typically model to predict behaviour. Those that use of many heterogeneous agents, so to speak, ‘interacting’, for instance? What makes a complex world, if not such agents? How (and how much) do origins, cultures and civilizations in which agents are embedded really matter? Does evolution matter as such? Does the brain (only) matter? Do moral values matter (to us)? If some of these queries receive positive answers, what does it imply with respect to agent-based modelling, macroManagerial decision economic modelling, econometrics, behavioural and experimental Managerial decision Economics, and so many other fields? This series of questions highlight a huge varsity of representations of the Managerial decision economic agent as well as the need for a wide spectrum of approaches to grasp it as efficiently as possible. As we investigate representational tools dealing with this agent in Managerial decision economic analysis, many levels of philosophical issues come to the fore: ontological, epistemological, methodological, psychological, ethical. Since Managerial decision economic philosophy must – insofar as it is a self-reflective inquiry on theory and practice of Managerial decision Economics – candidly face these issues, an articulation and clarification of their practical consequences in terms of decision, justice, welfare (and on many other topics) is needed to depict and represent the Managerial decision economic agent satisfyingly.

As research in decision-making behaviour becomes computational, it incorporates approaches from theoretical biology, computer science and mathematics. Neuroabsenteeism adds by using methods in understanding interplay between absence behaviour and neural mechanisms. By using tools from various fields, Neuroabsenteeism offers a more integrative way of understanding decision making. It offers solution through an additional set of statistics obtained via a series of measurements of brain activity at the time of decisions. The study of decision making requires extensive empirical study and setting for basic research on how ill-structured problems are, and can be, solved. It proposes a number of methodological studies to develop implementation proposition methods including studies into: guideline development and presenteeism development of a method for assessing guidelines for absence assessment, development of a framework for evaluating and adapting guidelines for local use, the design, conduct and analysis of cluster randomized trials and interrupted time series designs. The study develops a cluster randomized sample size to develop practical tools to support implementation researchers alongside ongoing programs of implementation.

Although there have always been links and interactions connecting Managerial decision Economics and philosophy, there exists a growing interest to constitute Managerial decision economic philosophy as an emerging field of research. What are the unsolved problems of neuroscience?  Undeniably, Managerial decision Economics involves making decisions that are not only methodological, but also epistemological and ontological. Very often these aspects are not directly questioned by economists. Managerial decision economic philosophy focuses specifically on these topics, since discussing them is a way to both criticize and to deepen Managerial decision economic theory and its implications. Thus, the specificity of Managerial decision economic philosophy is that it is not so much a discourse on, as a discourse within Managerial decision Economics; it is an internal reflexivity in Managerial decision Economics. In order to be able to really tackle all these specific questions, it is fruitful to blend the approaches of philosophy and Managerial decision Economics (although certainly a broader need for a multidisciplinary communication and collaboration is not limited to these two disciplines). In order to offer some framework for interaction, three major axes of interaction connecting philosophy and Managerial decision Economics can be identified: (a) moral and political philosophy and normative Managerial decision Economics, (b) philosophy of sciences and Managerial decision economic methodology, (c) narration of philosophy and narration of Managerial decision economic thought. Nonetheless, independently of the chosen perspective (ethical, epistemological, or historical) it is the coexistence of these two disciplines that is, according to us, a necessary condition for interactions connecting them.

How can we leverage our brain in business? How can we capitalise / invest on the brain? How can we make the best decision? How can we find the productivity ‘hot buttons’ in the brain? How can we encourage creative and ethical brain? What is the nature of explanation in Managerial neuro - Economics? What information about the past is relevant to Managerial neuro - economic decision making? What past experiences cannot be ‘unlearned’ in view of subsequent developments? How does experience influence our decisions? What kinds of experiences would produce better decisions and better adaptation? How does experience transfer to new situations? What learning processes take place during sampling and repeated consequential decisions? How do these processes alter when decisions are interrelated over time? When feedbacks are delayed? When decisions are time-dependent? How do we address consequential and sampling decisions when the ‘environment’ is dynamic? When it involves other individuals? What learning processes take place during sampling and repeated consequential decisions? How do these processes alter when decisions are interrelated over time? When feedbacks are delayed? When decisions are time-dependent? How do we address consequential and sampling decisions when the ‘environment’ is dynamic? When it involves other individuals? How do Managers make decisions in dynamic stock management tasks? How do Managers perceive accumulation over time? Why do Managers perform so poorly at control tasks? How can judgments of accumulation be improved? What are the effects of feedback complexity and feedback delays? How are theories represented in computational models? How can we validate and test theories/hypotheses with computational models? What is the value of using video games and simulations in behavioural decision research? How can we best present, measure, and analyse data on human learning? How do Managers make inferences from numbers? How do Managers process logic representations of data relationships? Is the representation of the past in any sense ‘rational’? Are affective as well as cognitive processes involved? Can the Managerial neuro - economic present rewrite the Managerial neuro - economic past? What are the implications of memory-dependence for modelling and policy-making? Is there place for emergence in Managerial neuro - economical explanations; in particular, how does one take into explanation downward causality? Is psychology indispensable for understanding of Managerial neuro - economical phenomena? What can and cannot one expect of mathematical modelling in Managerial neuro - Economics? Does Managerial neuro - Economics have an ontologically sound domain? How dissimilar are biological systems and Managerial neuro - economical ones? Is an analysis of various notions of rationality (including bounded rationality) still important, and if so, why? What is bounded rationality? A complete answer to this question cannot be given at the present state of the art. However, empirical findings put limits to the concept and indicate in which direction further inquiry should go. What has philosophy of Managerial neuro - Economics to say about the present crisis? What has philosophy to offer the methodology of behavioural Managerial neuro - Economics and neuroManagerial Economics?

This notion has a rich narration. Herbert Simon remarked that ‘there is a complete lack of evidence that, in actual human decision situations of any complexity, … [rational] computations can be, or are in fact, performed … but we cannot, of course, rule out the possibility that the unconscious is a better decision maker than the conscious’. We model the decision process under uncertainty as a problem in maximization governed by mental processes, the traces of which have observable neural correlates in brain imaging. The current model breathes meaning into unconscious computational processes associated with decision under uncertainty, its inherent error properties, and its observational content. Moreover, it offers a substantial extension to the interpretation that ‘if subjects implicitly take explanation of the effort cost of decision, then of course the subject's unconscious decisions are indeed better-super rational-than the conscious rational decision analysis predictions of the theorist/experimentalist’.

In further development of his thoughts on human decision, Simon noted that the necessity for careful distinctions between subjective rationality (… given the perceptual and evaluation premises of the subject), and objective rationality (… as viewed by the experimenter) … in the explanation of observed behaviour … to predict how Managerial decision economic man will behave we need to know not only that he is rational, but how he perceives the world—what alternatives he sees, and what consequences he attaches to them. … We should not jump to the conclusion, however, that we can consequently get along without the concept of rationality.

Model does not jump to any such conclusion and explicitly builds on both subjective and objective elements in decisions, and derives the observational implications of varying the parameters of those elements. Models of subjective effort-costly decisions imply the nonexistence of any coherent concept of objective rationality for individual decisions, alike for all. But ‘there is no denial of human rationality; the issue is in what senses are individuals rational and how far can we go with abstract objective principles of how ‘rational’ Managers ‘should’ act’. Siegel acknowledged the key influence of Simon's notion in leading him to model a hypothesized tradeoff between the subjective cost of executing a decision task (‘boredom’) and monetary rewards in the particular context of predicting Bernoulli trials. When theory fails experimental tests, a common reaction is to suppose that the rewards for decisions must not have been large enough to matter. This view has intuitive appeal, but it is devoid of empirical (predictive) content, in the absence of building on the perception to reformulate standard theory. Also, it implies that Managerial decision economics is only about decisions in which rewards are large enough to matter and consequently does not address most of the day-to-day Managerial decision economic decisions of life.

Experimentalists have argued that this phenomenon may be a natural consequence of other motivations, besides monetary reward, that are arguments in individual utility functions. Thus Smith suggested that the use of monetary rewards to induce pre-specified a value on decisions may be compromised by several considerations, one being the presence of transactions effort, generalizing Siegel, who systematically varied reward levels to measure the effect on subjective decision cost in his model of binary decision prediction. The ‘failure to optimize’ (i.e., objectively) can be related to what von Winderfelt and Edwards called the problem of flat maxima, that is, a consequence of the low opportunity cost for deviations from the ‘optimal’ outcome, as emphasized by Harrison. This perception led to the interpretation that because standard theory predicts that decision makers will make optimal decisions, despite how gently rounded the payoff function is, the theory is misspecified and needs modification. When the theory is properly specified, there should be nothing left to say about opportunity cost or flat maxima (i.e., when the benefit margin is weighed against decision cost, there should be nothing left to forgo).

What keeps this statement from being tautological is that it leads to predictions that are testable. Although one can look backward to the preceding (not exhaustive) literature review on decision cost, there are significant gaps in the previous work, which fails to provide a comprehensive formal treatment that predicts decisions, response times, error rates, and brain activation in a decision maker. For example, Smith and Walker showed that increasing the reward to decision (or decreasing decision cost) (i) increases effort, where effort is a postulated, unobserved intermediate variable, and (ii) increases the variance of decision error, which is their only observational prediction. By further postulating that increased experience lowers decision cost, they are able to conclude that increased experience will lower the variance of decision error, but there is no formal parametric treatment of experience. For example, Smith and Walker reported first-price auctions in which reward levels and experience were systematically varied and found that the error variance declined both with increased reward and with increased experience.

This notion has provided a simple and testable setup for a theory of the decision process. It suggests a new direction of research in the investigation of the behavioural and neural foundation of the difference between the effects that operate through an improvement in the signal and those operating through a reduction of the cost of information processing. The interest of this distinction is clear from our results: A decrease in the marginal cost increases optimal effort, whereas the increase in the effectiveness of the effort has a nonmonotonic effect, through the combined effect of the complement and substitution effect.

It goes without saying that how the ‘Managerial decision economic agent’ is represented does matter to the utmost. It matters as much for Managerial decision economic theory as for empirical investigations that are based upon such models. It matters in the way institutions emerge, as to how societies get organised, and for the many devices contributing to the ‘general good’ (whether they appear spontaneously, or are pragmatically and purposely created). It matters also for correcting incomplete or missing markets. As Managerial decision Economics represents and models society, Managerial decision economic analysis relies on ‘representational tools’ towards a better understanding of the Managerial decision economic world. Managerial cognition plays an important role in the evolution of capabilities. Sensing is regarded as an important aspect of dynamic capabilities and there is an increasing amount of evidence of how the evolutionary patterns of organisations are shaped by beliefs and organisational attention allocation dynamics. There are yet unsolved problems in Managerial cognition, although some of these problems have evidence supporting a hypothesized solution, and the field is rapidly evolving. This section attempts at addressing three areas:

**Challenges**

NeuroManagerial economic decision making neuroscience research, as currently practiced, employs the methods of neuroscience to investigate concepts drawn from the socio - Managerial sciences. A typical study selects one or more variables from psychological or economic models, manipulates or measures decisions within a simplified decision task, and then identifies neural correlates. Using this ‘neuroeconomic’ approach, researchers have described brain systems whose functioning shapes key economic variables, most notably aspects of subjective value. Yet, the standard approach has fundamental limitations. Important aspects of the mechanisms of neuroManagerial economic decision making – from the sources of variability in neuroManagerial economic decision making to the very computations supported by neuroManagerial economic decision making-related regions – remain incompletely understood. NeuroManagerial economic decision making neuroscience, including its subfield of neuroeconomics, has provided new insights into the mechanisms that underlie a wide range of economic and socio - Managerial phenomena, from risky decision and temporal discounting to altruism and cooperation. However, its greatest successes clearly lie within one domain: identifying and mapping neural signals for value. Canonical results include the linking of dopaminergic neuron activity to information about current and future rewards (Schultz et al., [1997](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B70)); the generalization of value signals from primary rewards to include money (Delgado et al., [2000](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B20); Knutson et al., [2001](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B43)), socio - Managerial stimuli and interpersonal interactions (Sanfey et al., [2003](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B68); King-Casas et al., [2005](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B42)); and the identification of neural Markers for economic transactions (Padoa-Schioppa and Assad, [2006](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B58); Plassmann et al., [2007](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B61)). And, in recent studies, these value signals can be shown to be simultaneously and automatically computed for complex stimuli (Hare et al.,[2008](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B32); Lebreton et al., [2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B48); Smith et al., [2010](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B74)). In all, research has coalesced on a common framework for the neural basis of valuation; for reviews see Platt and Huettel ([2008](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B62)), Rangel et al. ([2008](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B64)), Kable and Glimcher ([2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B39)).Despite these successes, other aspects of the neural basis of neuroManagerial economic decision making remain much less well understood. Even where there has been significant progress – as in elucidating the neural basis of other neuroManagerial economic decision making variables like probability and temporal delay – there remain key open and unanswered questions. Below are described ten major problems for future research in neuroManagerial economic decision making neuroscience (Table [​(Table1).1](http://europepmc.org/articles/PMC2948450/table/T1/)). By focusing on theoretical and conceptual challenges specific toneuroManagerial economic decision making neuroscience, this review necessarily omits important future methodological advances that will shape all of neuroscience: applications to new populations, longitudinal analyses of individuals, genomic advances, and new technical advances (e.g., linking single-unit and fMRI studies). Even with these caveats, this list provides a broad overview of the capabilities of and challenges facing this new discipline.

**Deconstructing Dual-Systems Mindset:** The most pervasive conceptual frameworks for neuroManagerial economic decision making neuroscience – and for neuroManagerial economic decision making science and even all of psychology, more generally – are dual-systems models. As typically framed, such models postulate that neuroManagerial economic decision makings result from the competitive interactions between two systems: one slow, effortful, deliberative, and foresightful, the other rapid, automatic, unconscious, and focused on the present state (Kahneman, [2003](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B40)). Considerable behavioural research supports key predictions of this class of models: e.g., time pressure and cognitive load have more limiting effects on deliberative than automatic judgments (Shiv and Fedorikhin,[1999](file:///C:\\Users\\samsung\\Desktop\\NEURO%20%20%20BANK\\NEURO%20%20%20WIKI\\41.htm" \l "B72)). Many neuroManagerial economic decision making neuroscience studies, including seminal work, have described their findings in dual-systems terms (Sanfey et al., [2003](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B68); McClure et al.,[2004a](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B53); De Martino et al., [2006](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B19)), typically linking regions like lateral prefrontal cortex to the slow deliberative system and regions like the ventral striatum and amygdala to the rapid automatic system. The dual-systems framework has been undoubtedly successful for psychological research, both by sparking studies of the contributions of affect to neuroManagerial economic decision making and by generating testable predictions for new experiments. Yet, it has had some unintended consequences for neuroManagerial economic decision making neuroscience, often because the psychological and neural instantiations of each system vary dramatically across studies. Psychological factors attributed to the emotional system include a range of disparate processes, from time pressure and anger to pain and temptation. Conversely, brain regions like the orbitofrontal cortex can be labeled as making cognitive or emotional contributions, in different contexts (Bechara et al., [2000](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B8); Schoenbaum et al., [2006](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B69); Pessoa, [2008](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B60)). Some key regions do not fit readily into either system; e.g., insula and dorsomedial prefrontal cortex, which may play important roles in shaping activation in other regions (Sridharan et al., [2008](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B77); Venkatraman et al., [2009a](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B84)). As a final and most general limitation, studies of functional connectivity throughout the brain indicate the often-simultaneous engagement of a larger set of functional systems (Beckmann et al., [2005](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B9); van den Heuvel et al., [2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B82)).The intuitiveness of the dual-system framework poses challenges for its replacement. Even so, considering models that involve a wider array of processes – each engaged according to task demands – would better match neuroManagerial economic decision making neuroscience to adaptive, flexible decision mechanisms (Payne et al., [1992](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B59); Gigerenzer and Goldstein, [1996](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B25)).

**Describing Neural Mechanisms of Self-Control Processes :** Self-control is a common construct in neuroManagerial economic decision making research, both in interpretations of real-world behaviour (Thaler and Shefrin, [1981](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B79); Baumeister et al., [2007](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B6)) and in explanations of neuroscience results (Hare et al., [2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B31)). Socio - Managerial psychology researchers have operationalized self-control as the ability to pursue long-term goals instead of immediate rewards. Cognitive psychology and neuroscience researchers often adopt a broader perspective: control processes shape our thoughts and actions in a goal-directed and context-dependent manner. Prior cognitive neuroscience research has linked control processing to the prefrontal cortex (PFC), specifically lateral PFC, which is assumed to modulate processing in other parts of the brain based on current goals (Miller and Cohen, [2001](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B56)). NeuroManagerial economic decision making neuroscience studies have argued that lateral PFC exerts an influence upon regions involved in the construction of value signals (Barraclough et al., [2004](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B5); McClure et al., [2004b](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B54); Plassmann et al., [2007](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B61)), potentially leading to the adaptive behaviours (e.g., delay of gratification) considered by socio - Managerial psychology research (Figner et al., [2010](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B23)).But, control demands are not identical across contexts, nor is control processing likely to be linked to one neural module. Even a unique link to PFC would be an oversimplification; across humans and other great apes the PFC constitutes approximately one-third of the brain, by volume (Semendeferi et al., [2002](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B71)). Accordingly, a core theme of cognitive neuroscience research has been to parse PFC according to distinct sub-regions’ contributions to control of behaviour. Considerable evidence now supports the idea that, within lateral PFC, more posterior regions contribute to the control of action in an immediate temporal context, while more anterior regions support more abstract, integrative, and planning-oriented processes (Koechlin et al., [2003](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B45); Badre and D'Esposito, [2007](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B4)). Recent work has extended this posterior-to-anterior organisation to dorsomedial PFC (Kouneiher et al., [2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B46); Venkatraman et al., [2009b](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B85)), which has often been implicated in processes related to reward evaluation.By connecting to this burgeoning literature on PFC organisation, neuroManagerial economic decision making neuroscience could move beyond simple reverse-inference interpretations of control (Poldrack, [2006](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B63)). Simple links can be made through increased specificity in descriptions of activation locations and their putative contributions to control (Hare et al., [2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B31)). Stronger links could be made through parallel experimentation. When a neuroManagerial economic decision making variable is mapped to a specific sub-region (e.g., the frontopolar cortex), researchers should also test non-neuroManagerial economic decision making-making tasks that challenge the hypothesized control processes of that region (e.g., relational integration). If the attributed function is correct, then both sorts of tasks should modulate the same brain region, ideally with similar effects of state and similar variability across individuals. Furthermore, manipulation techniques like transcranial magnetic stimulation should not only alter preferences and decisions in the neuroManagerial economic decision making task, but also should influence performance in the simpler non-neuroManagerial economic decision making context – providing converging evidence for the underlying control processes.

**Distinguishing Forms of Uncertainty:** Uncertainty pervades neuroManagerial economic decision making. Nearly all real-world decisions involve some form of psychological uncertainty, whether about the likelihood of an event or about the nature of future preferences. Most studies in neuroManagerial economic decision making neuroscience literature – like in its counterparts in the socio - Managerial sciences – have examined the effects of risk; for reviews see Knutson and Bossaerts ([2007](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B44)), Platt and Huettel ([2008](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B62)), Rushworth and Behrens ([2008](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B66)). While definitions vary across contexts, a ‘risky neuroManagerial economic decision making’ involves potential outcomes that are known but probabilistic, such that risk increases with variance among those outcomes, potentially normalized by the expected value (Weber et al., [2004](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B86)). Uncertainty can have other forms, however. Outcomes may be known but occur with unknown probability; such neuroManagerial economic decision makings reflect ambiguity (Ellsberg, [1961](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B22)). Only a handful of studies, so far, have investigated the neural basis of ambiguity (Smith et al., [2002](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B75); Hsu et al., [2005](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B36); Huettel et al., [2006](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B37); Bach et al., [2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B3)). And, still other states of uncertainty might be evoked in cases where the outcomes themselves are unknown, as is the case in complex real-world neuroManagerial economic decision makings. So far, neuroManagerial economic decision making neuroscience research has established weak, albeit numerous, links between uncertainty and its neural substrates. During active neuroManagerial economic decision making, risk modulates regions of lateral prefrontal cortex, parietal cortex, and anterior insular cortex (Mohr et al., [2010](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B57)), all of which contribute to the adaptive control of other aspects of behaviour. Yet, risk also influences activation in other regions seemingly associated with simpler sensory, motor, or attentional processes (McCoy and Platt, [2005](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B55)), as well as in the brain's reward system directly (Berns et al., [2001](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B11); Fiorillo et al., [2003](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B24)). The presence of ambiguity likewise modulates activation in both regions that support executive control (Huettel et al., [2006](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B37)) and regions that track aversive outcomes (Hsu et al., [2005](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B36)). In some of the above studies, these brain regions have been linked to the characteristics of the neuroManagerial economic decision making problem, in others to the decisions made by a participant, and in still others to individual differences in uncertainty aversion. Still needed are characterizations of both common and distinct computational demands associated with different sorts of uncertainty – which would in turn provide new insights into neural function.

**Establishing Framework for Temporal Discounting:** NeuroManagerial economic decision making neuroscience research has long sought to understand the neural mechanisms of temporal discounting (Luhmann; [2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B50)). Much of the recent debate in this area has revolved around questions of value: Do rewards available at different delays engage distinct value systems, such as a rapid, immediate system versus a patient, delayed system (McClure et al., [2004a](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B53))? Conversely, other evidence indicates that immediate rewards have no special status, at least in the monetary domain; they engage the same value system as observed for more distal rewards (Kable and Glimcher; [2007](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B38)).Monetary value, however, constitutes an unnatural reward for discounting experiments. The same research subject who discounts rewards by 5% per month – as when indifferent between $40 now and $42 four weeks later – might simultaneously evince discounting of few percent a year in their financial investments. This participant, who would likely be coded as relatively ‘patient’, evinces a laboratory discount rate more than an order of magnitude faster than that of typical real-world monetary investments. Even more strikingly, non-human animals often discount rewards completely within a few seconds (Mazur, [1987](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B51)). Some differences in discount rate may come from task effects; e.g., animals are tested during reward learning while humans are asked about the value of prospective rewards. However, reward modality also affects discount rate: When human subjects make neuroManagerial economic decision makings about primary and socio - Managerial rewards, they show appreciable discounting within the seconds-to-minutes range (Hayden et al., [2007](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B33); McClure et al., [2007](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B52)). Non-monetary rewards, consequently, may represent a better model for evolutionarily conserved processes of discounting.The vast range of temporal discounting behaviour – from patient real-world investments to impulsive laboratory decisions – presents both a challenge and an opportunity. Research using human participants will need to test a wider range of rewards – both primary rewards like juice and more complex rewards like visual experiences (McClure et al., [2007](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B52)) – and will need within-participant comparisons to monetary stimuli. By investigating individual differences in resistance to immediate rewards, more generally, researchers may identify interactions between control-related regions and value-related regions that together shape intertemporal decision (Hare et al., [2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B31)). And, research will need better links to the well-established literature on interval timing (Buhusi and Meck, [2005](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B15)); for example, parallel manipulations of time perception could provide a bridge between discounting phenomena and the associated neural processes. Through such integrative approaches, new research will provide more satisfying answers to core neuroManagerial economic decision making neuroscience questions about differences in processing of temporally immediate and distant rewards.

**Reconciling Conceptual Frameworks:** For the dual-systems model to be replaced, simple criticisms will be insufficient – new models must be set forth in its place. Ideally, any replacement model should build upon cutting-edge findings in cognitive neuroscience about how brain systems are organised and interact. Yet, there is a conceptual disconnect between neuroManagerial economic decision making neuroscience and cognitive neuroscience. In neuroManagerial economic decision making neuroscience, concepts are typically described in terms of their behavioural consequences (e.g., temporal discounting) or neuroManagerial economic decision making variables (e.g., risk, ambiguity); i.e., contributions to a model of behaviour. In cognitive science and cognitive neuroscience, however, functional concepts are typically described in terms of their contributions to a model of process (e.g., inhibition, working memory). Without reconciling these concepts, research in each field will continue apace.The key challenge, accordingly, will be to create a functional taxonomy that maps neuroManagerial economic decision making behaviour onto its underlying process. Because most economic models predict decisions, but do not describe the decision process, they may have only an ‘as if’ relationship to mechanisms. Each variable or operation in the model results from a host of independent computations, many of which may correspond to specific functions studied by cognitive neuroscience. To elucidate these relations will require two changes to typical neuroManagerial economic decision making-neuroscience methods. First, psychological studies of neuroManagerial economic decision making-making behaviour can decompose key processes; e.g., interference observed in a dual-task paradigm can reveal that the primary neuroManagerial economic decision making process relies on the secondary process. Second, parallel measurement of cognitive tasks alongside neuroManagerial economic decision making-making tasks can strengthen functional claims, especially when an individual-difference variable or external manipulation exerts similar effects on multiple measures.

**Determining Neural Basis:** Early integrations of behavioural economics and psychology shared a common perspective: individuals vary in their approaches to neuroManagerial economic decision making, especially in realistic scenarios (Simon, [1959](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B73); Tversky and Kahneman, [1974](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B81)). Individuals can choose based on complex rules that involve compensatory trade-offs between neuroManagerial economic decision making variables or based on simplifying rules that ignore some information and emphasize other, depending on immediate task demands (Payne et al., [1992](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B59)). Yet, the nature of most neuroscience experimentation discourages analysis of strategic, meta-neuroManagerial economic decision making processes. The fMRI signal associated with a single neuroManagerial economic decision making is relatively small, compared to ongoing noise, while PET and TMS studies collapse across all neuroManagerial economic decision makings in an entire experimental session. Thus, trial-to-trial variability is an infrequent target for analyses. Tasks in most studies are simple, with small stakes (e.g., tens to hundreds of dollars) obtained over a short duration, reducing the incentive to explore the full space of possible neuroManagerial economic decision making strategies. Participants are often well-practiced, especially in non-human primate single-unit studies that can involve thousands of trials; this can lead to stereotypy of behaviour. Moreover, meta-neuroManagerial economic decision making processing can be difficult to model – in many contexts, different strategies could lead to the same expressed behaviour. Despite the challenges of describing strategic aspects of neuroManagerial economic decision making, such analyses will become increasingly feasible. Neuroimaging techniques, in particular, provide an unique advantage by characterizing large-scale functional relationships, via recent advances in connectivity analyses (Buckner et al., [2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B14); Greicius et al., [2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B27)). The explosion of interest in condition-specific connectivity modeling, functional mediation analyses, and similar techniques will provide new insights into how the same brain regions can support very different sorts of behaviour, across individuals and contexts. Moreover, proof-of-concept examples can be seen in domains where a priori models exist – as in cases of exploration/exploitation (Daw et al., [2006](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B18)) or compensatory/heuristic decision (Venkatraman et al., [2009a](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B84)).

**Moving from Single Traits to Composite Factors:** Some of the most striking results in neuroManagerial economic decision making neuroscience link specific brain regions to complex cognitive traits. Most such examples come from across-subjects correlations between trait scores– whether derived based on observed behaviour or self-reported on a questionnaire – and fMRI activation associated with a relevant task. In recent years, researchers have identified potential neural correlates for behaviours and traits as diverse as reward sensitivity (Beaver et al., [2006](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B7)), Machiavellian personality (Spitzer et al., [2007](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B76)), loss aversion (Tom et al., [2007](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B80)), and altruism (Tankersley et al., [2007](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B78); Hare et al., [2010](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B30)). Trait-to-brain correlations, in themselves, provide only limited information about the specific processes supported by the associated brain regions. Due to the small sample sizes of fMRI research, relatively few studies adopt the methods of socio - Managerial and personality psychology. Even if a single trait is desired, incorporating related measures can improve specificity of claims; e.g., identifying the effects of altruism, controlling for empathy and theory-of-mind. In other areas of cognitive psychology, for example, measures of processing speed, memory, and other basic abilities can predict individual differences in more complex cognitive functions (Salthouse, [1996](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B67)). And, factor and cluster analyses can take a set of related measures and derive composite traits – or can segment a sample into groups with shared characteristics, as frequently done in clinical settings. Improved trait measures will also facilitate genomic analyses; single genes will rarely match to traditional trait measures, making identification of robust traits crucial for multi-gene analyses.

**Using State Effects to Build Convergent Models :** Decisions depend on one's internal state. Long-recognized have been the effects of emotion and mood states; e.g., anger can lead to impulsive and overly optimistic decisions, while fear and sadness can lead to considered, analytic, but pessimistic decisions (Lerner and Keltner, [2001](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B49)). Sleep deprivation leads to attentional lapses and to impairments in memory, reducing the quality of subsequent neuroManagerial economic decision makings and increasing risk-seeking behaviour (Killgore et al., [2006](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B41)), with concomitant effects on brain function (Venkatraman ; [2007](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B83)). And, state manipulations of key neurotransmitter systems can have effects similar to those of chronic drug abuse and of brain damage (Rogers et al., [1999](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B65)). Given the wide variety of phenomena investigated, the study of state effects provides some of the clearest applications for neuroManagerial economic decision making neuroscience research. The standard approach, so far, has been the characterization (cataloging) of each state effect separately. That is, researchers adopt a paradigm used in prior neuroManagerial economic decision making neuroscience research and then measure how a single manipulation of state alters the functioning of targeted brain regions. The result has been a collection of independent observations – each valuable in itself, but difficult to combine. A challenge for subsequent research, consequently, will be to create mechanistic models that allow generalization across a range of states. For one potential direction, consider the growing evidence that emotion interacts with cognitive control in a complex, and not necessarily antagonistic, manner (Gray et al., [2002](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B26); Pessoa, [2008](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B60)). A general model of control would need to predict the effects of individual difference variables across several states; e.g., how trait impulsiveness influences decisions under anger, following sleep deprivation, and after consumption of alcohol. Even more problematic will be creating models that explanation for combinations of states, such as interactions between drug abuse and depression. A key milestone for the maturity of neuroManagerial economic decision making neuroscience, as a discipline, will be the development of biologically plausible models that can predict behaviour across a range of states.

**Identifying Domain Specificity:** Research in neuroManagerial economic decision making neuroscience is often motivated via examples from evolutionary biology. A canonical example comes from the domain of resource acquisition (e.g., foraging): Humans and other animals must identify potential sources of food in their local environment, each of which may lead to positive (e.g., nourishment) or negative (e.g., predation) consequences with different likelihoods. Thus, organisms have evolved with faculties for learning and deciding among options with benefits, costs, and probabilities – and the expression of these faculties in the modern environment results in the general models of neuroManagerial economic decision making-making found within economics and psychology (Weber et al., [2004](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B86)). While such examples can provide important insights into the behaviour of humans and our primate relatives, they also can lead to simple, ad hoc (or ‘just-so’) explanations based on evolutionary pressures. An important new direction for neuroManagerial economic decision making neuroscience will lie in the evaluation of potential domain specificity. Different sorts of neuroManagerial economic decision making problems may led to different sorts of selection pressures. For example, compared to foraging neuroManagerial economic decision makings, decisions in socio - Managerial contexts may have dramatically different properties. Our socio - Managerial neuroManagerial economic decision makings can be infrequent but have long-lasting consequences, poor socio - Managerial neuroManagerial economic decision makings limit the space of our future interactions, and all socio - Managerial interactions are made in a dynamic landscape altered by others’ behaviour. Some of these features may change the cognitive processing necessary for adaptive socio - Managerial neuroManagerial economic decision makings, resulting in distinct neural substrates (Behrens et al., [2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B10)). Because of this potential variability, neuroManagerial economic decision making neuroscience will need to consider how domains shape neuroManagerial economic decision making-making priors – the biases (and even mechanisms) that Managers bring to a neuroManagerial economic decision making problem. A focus on contextual priors has been very profitable in explaining other adaptive behaviours; perceptual biases, for example, reflect the natural statistics of our visual environment (Howe and Purves, [2002](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B35); Weiss et al., [2002](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B87)). By identifying and characterizing distinct domains of neuroManagerial economic decision making, and by understanding the natural properties of those domains, researchers will be better able to construct models that span both individual and socio - Managerial neuroManagerial economic decision making.

**Generalizing Decisions Outside Laboratory:** Concepts and paradigms from neuroManagerial economic decision making have had unquestionably salutary effects on neuroscience research. Neuroscience, conversely, has had a much more limited influence on neuroManagerial economic decision making-making research in the socio - Managerial sciences. Concepts from neuroManagerial economic decision making neuroscience now appear in the marketing (Hedgcock and Rao, [2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B34)), game theory (Bhatt and Camerer, [2005](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B12)), finance (Bossaerts, [2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B13)), and economics (Caplin and Dean, [2008](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B16)) literatures. In several striking examples, researchers have used neuroManagerial economic decision making neuroscience experimentation to guide mechanism design in auctions (Delgado et al., [2008](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B21)) and allocation of public goods (Krajbich et al.,[2009](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B47)). These sorts of conceptual influences can be labeled ‘weak neuroManagerial economic decision making neuroscience’, or the study of brain function to provide insight into potential regularities, without making novel predictions about real-world decisions. The most difficult challenge for future research will be to use neuroscience data, which by definition are collected in limited samples in laboratory settings, to predict the patterns of decisions made by the larger population. Predictive power will be unlikely to come from the traditional experimental methods of cognitive neuroscience, which typically seek to predict an individual's behaviour based on their brain function (and thus cannot scale to the larger population). There are compelling arguments that, even in principle, no neuroManagerial economic decision making neuroscience experiment can falsify or prove any socio - Managerial science model (Clithero et al., [2008](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B17); Gul and Pesendorfer, [2008](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B28)).

The goal of a ‘strong neuroManagerial economic decision making neuroscience’– i.e., to use a single neuroManagerial economic decision making-neuroscience experiment to shape economic modeling or to guide a real-world policy – may be unattainable with conventional methods. However, this goal requires too much of neuroManagerial economic decision making neuroscience, in isolation (Clithero et al., [2008](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B17)). The ability to better predict real-world decisions will come from the iterative combination of neuroscience methods with measures of decision behaviour, with the specific goal of using neuroscience to constrain the space of needed behavioural experiments. By identifying biologically plausible models and potentially productive lines of experimentation, neuroManagerial economic decision making neuroscience will speed the generation of novel predictions and better models.

Sen notes how the ‘internal consistency’ approach and the ‘self-interest pursuit ‘approach are often conflated. In the ‘self-interest pursuit’ approach, whatever is defined as our preferences (represented by a utility function which, remember, is also taken to reflect our welfare) determines which option will be chosen. So, in the latter approach, preferences, utility, welfare and neuroeconomic Managerial decision are represented by the same ordering, and to define preferences and utility according to any of the first two interpretations of utility (viz., ‘happiness’ and ‘desire-fulfilment’) would lead us to identify the latter with the third interpretation of utility (namely, ‘neuroeconomic Managerial decision’). Analogously, in the ‘internal consistency’ approach, whatever neuroeconomic Managerial decision is made is supposed to be the utility (and welfare) optimising neuroeconomic Managerial decision – in fact, such a neuroeconomic Managerial decision only ‘reveals’ the ‘preference’ that led to it in the first place – so the same identity between all concepts follows. Hence, in both approaches, welfare, neuroeconomic Managerial decision and preference imply the same ordering (and rank) of options. Furthermore, in both approaches, this ordering must be a complete ordering, which enables us to predict neuroeconomic Managerial decisions. Sen notes how even though the two approaches are ‘fundamentally different’ (Sen 2002:226) they are confounded in this way in standard microneuroManagerial coherent theory because self-interest and utility are defined through the binary relation of revealed preference5. This is why both these approaches lead to the same results, and to an identification of neuroeconomic Managerial decision with preferences and welfare. The assumption that rational behaviour can be described through a complete preference ordering combined with the usual assumption that rational behaviour mimics or approximates actual behaviour, enables the use of rational neuroeconomic Managerial decision theory for predictive purposes. As Sen argues: ‘[T]he use of ‘rational neuroeconomic Managerial decision’ in neuroManagerial coherent s and related disciplines is very often indirect, particularly as a predicting device for actual behaviour, and this can often overshadow the direct use of rationality. That indirect program is geared to the prognostication of actual behaviour by first characterizing rational behaviour, and then assuming that actual behaviour will coincide with rational behaviour, or at least approximate it. In this indirect use, the idea of rationality plays an intermediating role in taking us to predictive analysis via the presumption of rational behaviour (combined with a view – typically a simple view – as to what makes a behaviour rational). A substantial part of the immediate appeal of this approach of ‘prediction via rationality’ lies in the tractability – and perhaps the simplification – that this procedure may provide’ (Sen 2002) In short, it is not a particular interpretation or use of concepts like ‘neuroeconomic Managerial decision’, ‘preference’, ‘welfare’, ‘utility’ and ‘self-interest’ that is central to mainstream neuroManagerial coherent theory – for these concepts are often conflated (or used in an ambiguous way) in mainstream neuroManagerial coherent theory – but rather the modelling of human behaviour in terms of exact regularities so as to enable prediction of events. The conception of rationality used in mainstream neuroManagerial coherent theory is thus subsidiary to the goal of predictability of events.

After criticising the explanations of rationality given by traditional rational neuroeconomic Managerial decision theory, Sen provides his own conception of rationality. According to Sen, rationality is neither the permanent exercise of self-interest pursuit, nor does it mean neuroeconomic Managerial decision (internally) consistent with some set of axioms. Rather, rationality is the discipline of subjecting competing options, goals and values to scrutiny: ‘Rationality is interpreted here, broadly, as the discipline of subjecting one´s neuroeconomic Managerial decisions – of actions as well as of objectives, values and priorities – to reasoned scrutiny. Rather than defining rationality in terms of some formulaic conditions that have been proposed in the literature (such as satisfying some prespecified axioms of ‘internal consistency of neuroeconomic Managerial decision’, or being in conformity with ‘intelligent pursuit of self-interest’, or being some variant of maximizing behaviour), rationality is seen here in much more general terms as the need to subject one’s neuroeconomic Managerial decisions to the demands of reason.’ (Sen 2002:4) Sen’s (1987, 1997, 2002) view of the human agent is one in which the latter is driven by a multiplicity of motivations other than self-interest, which not only may reflect different preference orderings, as they may not even lead to a complete ordering. For Sen, rationality neither means that one of these motivations (like self-interest) must dominate all others, nor does it mean that actual behaviour (or any of our competing objectives, goals or values) can be described by a complete preference ordering. Rationality, as the discipline of scrutinising our actions, objectives, motivations, goals and values, means not the conformity of behaviour to any preference ordering at all, but rather the possibility of revising and changing preference orderings.

So far, the field of neuroManagerial economic decision making neuroscience reflects a particular merging of disciplines: It integrates concepts from economics and cognitive psychology with the research methods of neuroscience. This combination has not only shaped understanding of the neural mechanisms that underlie neuroManagerial economic decision making, it has influenced how researchers approach problems throughout the cognitive neurosciences – as one of many examples, consider recent work on the interactions between reward and memory (Adcock et al., [2006](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B1); Axmacher et al., [2010](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B2); Han et al., [2010](file:///C:\Users\samsung\Desktop\NEURO%20%20%20BANK\NEURO%20%20%20WIKI\41.htm#B29)).Yet, fundamental problems remain. Some will be resolved over the coming years through new analysis techniques, novel experimental tasks, or the accumulation of new data. Other, more difficult problems may not be addressable using the methods typical to current studies. They require, instead, a reversal of the traditional approach – changing to one that integrates research methods from economics and psychology (e.g., econometrics, psychometric analyses) with conceptual models from neuroscience (topographic functional maps, computational biology). In doing so, neuroManagerial economic decision making neuroscience can extend the progress it has made in understanding value to the full range of decision phenomena.

Contributions of cognition research to the strategy process research, major challenges of strategy process and practice research and how cognition research could be used to alleviate them and promising intersections of the two research streams and some of the most exciting future research avenues to explore. How and where does the brain evaluate reward value and effort (cost) to modulate conduct? How does previous experience alter perception and conduct? What are the genetic and environmental contributions to brain function? During the past decade research on Managerial and organisation cognition has attracted increasing attention. Hence, how to represent the Managerial decision economic agent plays a crucial role and remains in all cases of major significance. The Managerial decision economic agent can be displayed in many ways, such as maximizing agent, possibly contrasted with rationally bounded (or ‘located’) agent, representative agent, possibly contrasted with agent of the agent-based modeling, and many others. The different kinds of representation can be complementary or can be (fully or partly) inconsistent. The various representations of agents imply different representations of the market(s), of the institution(s), and of ‘spheres’ where agents appear (spheres of interaction, spheres of justice and spheres of power), spheres where are different from markets. Is Managerial neuro - Economics possible without a growth ideology? What has neuroManagerial neuro - Economics contributed to long-standing problems in Managerial neuro - Economics, in particular those that hinge on Managerial neuro - economic agents not being rational? What new problems have neuroManagerial neuro - Economics suggested? How do neuroManagerial neuro - Economics propose to tackle problem of inferring causality from correlation? How precisely are Managerial neuro - economic constructs such as personal utility functions are supposed to be encoded in neurophysiologic structures? How does neuroManagerial neuro - Economics suggest treating Managerial neuro - economic decisions constrained by factors beyond individual Managerial neuro - economic agent? How do evolutionary psychology and neuroManagerial neuro - Economics co-exist? Why does neuroManagerial neuro - Economics put such an emphasis on non-human studies, which clearly cannot cover most Managerial neuro - economic situations (cutting a cake fairly, ultimatum game, etc.)? What insights do neuroManagerial neuro - Economics have for mathematical modelling in Managerial neuro - Economics? How does neuroManagerial neuro - Economics describe memory in Managerial neuro - economic agents? How can insights from behavioural and neuroManagerial neuro - Economics be embedded in Managerial neuro - economic models? What is the best way to model the interaction between affective and cognitive processes underlying Managerial neuro - economic decision taking? Can cognitive learning processes eventually override affective influences on Managerial neuro - economic decision taking? How do we spot the selection of the small number of items that the working memory can juggle when Managerial neuro - economic decisions are taken? What are the Managerial neuro - economic implications of modelling the brain as a relay of hysteretic processes? Which cognitive biases are magnified and which are diminished? Over what timescales do dissimilar aspects of behavioural Managerial neuro manifest them? How conventional Managerial decision economists are persuaded to take on board the findings of behavioural Managerial neuro - Economics and incorporate them into their models. Are more convincing experiments required, and if so, what needs to be addressed? How do heuristics alter in the presence of increased uncertainty? How is information coded in neural activity? How are memories stored and retrieved? What does the baseline activity in the brain represent? How do brains simulate the future? What are emotions? What is intelligence? How is time represented in the brain? Why do brains sleep and dream? How do the specialized systems of the brain integrate with one another? What is consciousness? Hemisphere Dominance of Brain Function--Which Functions Are Lateralized and Why? What Is the Function of the Thalamus? What Is a Neuronal Map, How Does It Arise, and What Is It Good For? What Is Fed Back? How Can the Brain Be So Fast? What Is the Neural Code? What Is the Other 85 Percent of V1 Doing? Which Computation Runs in Visual Cortical Columns? Are Neurons Adapted for Specific Computations? How Is Time Represented in the Brain? How General Are Neural Codes in Sensory Systems? How Does the Hearing System Perform Auditory Scene Analysis? How Does Our Visual System Achieve Shift and Size Invariance? What Is Reflected in Sensory Neocortical Activity: External Stimuli or What the Cortex Does with Them? Do Perception and Action Result from Different Brain Circuits? What Are the Projective Fields of Cortical Neurons? How Are the Features of Objects Integrated into Perceptual Wholes That Are Selected by Attention? Where Are the Switches on This Thing? How do brains balance plasticity against retention? How and where does the brain evaluate [reward](https://en.wikipedia.org/wiki/Reward_system) value and effort (cost) to modulate conduct? How does previous experience alter perception and conduct? What are the genetic and environmental contributions to brain function? How can the findings of behavioural Managerial neuro - Economics best be incorporated within a mathematical framework? How do the decision-making processes of individuals differ from those of organisations? Does this require a dissimilar modelling approach in each case?

Some issues that surge out of the above are;

**Interactions between Cognition and Emotion in Decision Making**

* What are the reciprocal relationships between cognitive and affective processes in decision-making?
* What are the neurobiological underpinnings of above interactions?
* How does emotional valence of information affect decision-making?
* How do emotional factors influence reward processing, perceptual judgments, preference formation and calculation of economic value or subjective utility?
* How do relationships between cognitive and emotional influences on decision-making alter over lifespan?
* To what degree can these alters be explained by alters in underlying neurobiological systems?
* What behavioural, computational, or neurobiological models capture interactions of cognition and emotion in decision-making?

**Individual Differences in Decision Making**

* How do individual differences in cognitive ability, temperament, or personality impact decision making across the lifespan?
* How do sex and gender influence decision-making?
* How do motivational state and goal orientation influence decision making across the lifespan?
* What neurobiological systems support different motivational states that drive decision-making?
* How does numeracy affect decision-making?
* Are low numerate individuals more likely to use intuitive rather than analytical processing, or reasoning that operates on gist rather than verbatim details?
* How consistent are discount rates for intertemporal decision across the lifespan?
* What psychological and neurobiological processes distinguish expert decision making from novice decision making?
* What are the pathways by which decision-making processes and experiences influence and are influenced by biological factors?
* How do environmental factors interact with biological processes to direct the development of decision-making capacities?
* How does decision making, in turn, influence neural processes through epigenetic processes or differences in genetic expression profiles?

**Socio - Managerial and Contextual Influences on Decision Making**

* How do interactions with family members, peers, subordinates, or authority figures impact decision making?
* How does the above context alter the interactions?
* What aspects of socio - Managerial relationships support or undermine effective decision-making?
* How is decision-making influenced by socioeconomic status and/or alters therein, limited resources, or scarcity?
* How can one define decision quality for individuals or groups in differing socioeconomic conditions?
* What are the effects of socio - Managerial norms, socio - Managerial pressures, and stigma on decision-making?
* How do factors such as time constraints, uncertainty, ambiguity, conflict, or stress impact decision making?
* How do ethical considerations and development of moral reasoning over lifespan influence decision making?
* How does making decisions for one differ from making decisions for or on behalf of others?
* How do long-term future outcomes vs. near-term considerations affect decision making for others?
* What factors influence the process and quality of group decision making?
* Do these differ as a function of life stage, group composition, or institutional context in which the decision is made?
* How does the structure of institutions, provision of information or nature of incentives affect decision-making?
* Do the above factors operate similarly across decision domains, across different age groups or gender, or across cultures?
* How do biological factors influence decision making in different contexts?
* How do environmental and biological factors affect brain development in ways that influence decision-making later in life?

The entire above give rise to a state of cognitive intricacy. Cognitive complexity can have various meanings; the number of mental structures we use, how abstract they are, and how elaborately they interact to shape our perceptions and ‘an individual-difference variable associated with a broad range of communication skills and related abilities ... [which] indexes the degree of differentiation, articulation, and integration within a cognitive system’. If elements in a grid are construed in the same fashion for all constructs then the organisation of the constructs is simple, they all lead to an identical prediction. There have been a number of alternative methods for generating an index of this ‘cognitive intricacy'. A tendency for constructs to be highly interrelated is sometimes termed monolithic construing. If the elements are construed in less related ways for all constructs then there is a more complex organisation leading to different predictions. Of course if the elements are construed in totally unrelated ways for all constructs then we have chaos in prediction, a totally fragmented set of constructs. Cognitive intricacy is a psychological characteristic or psychological variable that indicates how complex or simple is the frame and perceptual skill of a Manager. A Manager who is measured high on cognitive intricacy tends to perceive nuances and subtle differences which a Manager with a lower measure, indicating less complex cognitive structure for task or activity, does not. Neuroeconomic program tends to combine or, at least, to connect neural data collected and selected by the Neuroscientists on one side, and the behavioural evidence derived from the economic experimental protocols, on the other side. Neurodecision Economics is a potential bridge for translational research. Neuroeconomic methods combine behavioural economic experiments to parameterise aspects of decision-making with neuroimaging techniques to record corresponding brain activity. First, neurodecision Economics derive theoretical predictions and an objective metric to examine ‘multilevel’ research approach that combines performance (behavioural) measures with intermediate measures between behaviour and neurobiology (neuroimaging) to describe decision-making across multiple levels of explanation. As such, ecologically valid behavioural paradigms closely mirror the physical mechanisms of reward processing. Second, neurodecision Economics offers a platform for neuroscience, decision Economics and psychology to develop a common language for interpreting decision making. Consequently, neurodecision Economics can offer promising endophenotypes that might help clarify basis of high heritability.

Making a decision implies that there are alternative decisions to be considered. In such a case we want not only to spot as many of these alternatives as possible but to choose the one that;

* Has the highest probability of success or effectiveness, and
* Best fits with our goals, desires, lifestyle, values, and so on.

Emerging neuroscience evidence suggests that sound and rational neuro - Economics decision making depends on prior accurate emotional processing. Somatic Marker hypothesis offers a systems-level neuroanatomical and cognitive framework for neuro - Economics decision making and its influence by emotion. Key idea is that neuro - Economics decision-making is a process influenced by Marker signals. This influence can occur at multiple levels of operation, some of which occur consciously and some occur non-consciously. The issues, because contemporary models ignore influence of emotions on neuro - Economics decision-making, that crop up is;

* What happens when we alter our minds and what are the algorithms?
* What computational mechanisms allow brain to adapt to changing circumstances and remain fault-tolerant and robust?
* How (and where) are value and probability combined in brain and what is the dynamics?
* To what degree do tracking utility computations generalize tasks that are more complex?
* Does an unmet need generate a tonic and progressively increasing signal (amounting ‘drive’) or does it manifest as a recurring episodic / phasic signal with increasing amplitude?
* Do higher-level deliberative processes rely similarly on multiple mechanisms, or a single, more tightly integrated (unitary) set of mechanisms?

Every decision is made within a decision environment, which is defined as collection of information, alternatives, values and preferences available at time of decision. Neuroscience evidence suggests that sound and rational neuro - management decision making depends on prior accurate emotional processing. An ideal decision environment would include all possible information, all of it accurate, and every possible alternative. Nonetheless, both information and alternatives are constrained because time and effort to gain information or spot alternatives are limited. Time constraint simply means that a decision must be made by a certain time. An understanding of what decision-making involves, together with a few effective techniques, will help produce better decisions.

Focal point is to understand;

* Neural processes underlying how we craft decisions and decisions.
* Understand mechanisms of decision-making using functional neuroimaging methodologies.
* Integrating interdisciplinary research towards contributing to decision neuroscience.

Objective is to put forward a model for neuro - Economics decision, in which interaction between variables of neuro - Economics decision processes are addressed via;

* [How does brain assign value to different options under consideration?](http://www.rnl.caltech.edu/research/index.html#ValueComputation)
* How does brain compare assigned values in order to design a decision?
* How is ‘process of valuation’ alterd when control is exerted?
* How is value computed in complex / abstract domains?
* How can Neuro - Economics be applied to design solutions to real - time problems?

Subsequent issues are,

* There is a need to attend as to how neuroscience can, and already has, benefited from Neuro - Economics’ unitary perspective, and
* How neuroscience has been enriched by taking explanation multiple specialized neural systems with potential research directions.

**Chaos in Managerial Decision Making:** Quite often it is argued that in the microscopic world of quantum mechanics the uncertain principle makes the world non-deterministic. And due to chaos in Managerial decision making similar things do appear in the macroscopic world of daily life. Beside the fact that both statements are wrong they are not helpful. Due to chaos in Managerial decision making, small causes may evolve in time and have tremendous effects. It leads to important effects with implications for management and business. This thesis discusses possible causes of chaos in Managerial decision making from a Managerial perspective. In decision making logic there are some rules how and when chaos in Managerial decision making is easy to describe. Almost everybody might have some understanding of the word chaos in Managerial decision making. At least in the sense as an ordinary dictionary defines it (great disorder or confusion). There is also a more elaborate definition of chaos in Managerial decision making in decision making logic. About 25 years ago inundation of publications dealing with chaos in Managerial decision making has come into motion. Unlike in many other such cases, they have left traces in ‘daily life’. Recently, chaos in Managerial decision making was used to show that Taylor's management theory can't be correct. The present thesis will not deal with possible shortcomings of Taylor's theory. It will give hints where logical considerations of chaos in Managerial decision making will become important for business / management. Which system will show chaos in Managerial decision making and which won't is one central question in most logical work about chaos in Managerial decision making. (The second question is how to describe it, if it is chaotic. It will be the central question of my next section.) Unfortunately, a global answer to the question has not been found yet. In decision making logic and math systems are normally defined by a set of equations. If all equations are entirely linear, chaos in Managerial decision making won't appear. This is obvious, because in a linear world everything is proportional to everything. I.e. a doubling of something will double other things but not quadruple. Consequently the above mentioned exponential growth can't be observed. Nonetheless, linearity is in most cases only an approximation to the real world. From this I have the bad news that chaos in Managerial decision making might lurk everywhere. The good news is that it will disappear, if nonlinearities are small enough. I.e. one can give (for certain classes of equations) exact proofs, whether their nonlinearity is big enough to cause chaos in Managerial decision making. For two reasons this is not too helpful for the present purpose. Firstly, the proofs are different for each class of equations and, evidentially, the infinite number of classes of equations couldn’t have been considered. Secondly, in management we often have rules how systems will evolve. Though they can be as rigorous as equations (cf. examples 1 and 2 above), their translation into math is not always possible. I will close this section with some rules of thumb. For pure statistical reason chaos in Managerial decision making becomes more and more likely with growing complexity of the system. Likely sources for chaotic behaviour are ‘if...then...’ decisions. A discontinuity is of course a non-linearity. How strong this non-linearity is depends heavily on the difference of the two decisions within an if...then... decision. In my first example the maximum effect was a delay of a few minutes, and there is a good chance of averaging out. In the second example its effect will be a different direction (in addition to the delay). And there is no realistic chance that it will be averaged out. After having given a few guidelines how to detect chaos in Managerial decision making, I will now deal with the maybe most important question. How to handle chaotic systems? There is no standard approach to deal with chaos in Managerial decision making. The best advice is to stay out of them. Of course, that is not always possible. The second best advice is not to ‘fight’ the almighty enemy. Though it sounds ridiculous, I've seen many Managers trying to calculate solutions for chaotic problems by using bigger and bigger computers.

**Cognitive Requirements for Managerial Behaviour**

Interpretation of Managerial activity in terms of neuroscience is typically concerned with extreme behaviours. This section is concerned to map out the neurophysiological and cognitive mechanisms at work across the spectrum of Managerial behaviours encountered in more day-to-day contexts. It proposes that the competing neuro-behavioural decisions systems (MEBDS) hypothesis ([Bickel et al., 2012b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B26)) captures well the range of Managerial behaviours that can be characterized as hyper- or hypo-activity in either the limbically-based impulsive system or the frontal-cortically based executive system with the corresponding level of activity encountered in the alternative brain region. This pattern of neurophysiological responding also features in the Somatic Marker Hypothesis ([Damasio, 1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B37)) and in Reinforcement Sensitivity Theory (RST; [Gray and McNaughton, 2000](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B57); [McNaughton and Corr, 2004](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B72)), which usefully extend the thesis in the direction of personality. In discussing these theories, the section has three purposes: to clarify the role of cognitive explanation in neuro-behavioural decision theory, to propose neuroeconomic Managerial decision picoeconomics ([Ainslie, 1992](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B1)) as the cognitive component of competing neuro-behavioural decision systems theory and to suggest solutions to the problems of imbalanced neurophysiological activity in Managerial behaviour. The first is accomplished through debate of the role of neuroeconomic Managerial decision picoeconomics in neuro-behavioural decision theory; the second, by consideration of adaptive-innovative cognitive styles ([Kirton, 2003](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B63)) in the construction of Managerial teams, a theme that can now be investigated by a dedicated research program that incorporates psychometric analysis of personality types and cognitive styles involved in Managerial decision-making and the underlying neurophysiological bases of such decision-making.

Managerial dysfunction has numerous outcomes, from the lack of an appropriate fit between the Managerial Organisation and its environment, through the inappropriate composition of task-based management teams, to the incompatible predispositions and behavioural styles of individual Managers. This section is concerned with the neurophysiological underpinnings of Managerial behaviours, in particular with the implications these have for the styles of decision-making and problem-solving Managers adopt and their appropriateness for the tasks in hand. Although the neurophysiological basis of behaviour in Managerial Organisations has attracted considerable research attention of late (e.g., [Butler and Senior, 2007a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B29),[b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B30); [Lee et al., 2007](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B67); [Lee and Chamberlain, 2007](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B68)), there has been some tendency to address particular aspects of Managerial behaviour such as trust, cooperation and conflict, reward processing and social interaction rather than to seek a broader framework of conceptualization and analysis for this central aspect of Managerial functioning. Worthy as these themes are, this section proposes that the competing neuro-behavioural decision systems hypothesis ([Bickel and Yi, 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B28)) captures the neurological bases of forms of Managerial excess that engender a pathological tendency to avoid risk on one hand and a more reckless tendency to discount the future consequences of current actions on the other.

Theories of Managerial behaviour and, in particular, prescriptions that derive from them, require a cognitive understanding of the nature of decision-making. The competing neuro-behavioural decisions systems (MEBDS), in common with other neurophysiologic explanation of behaviour, tend not to have a well-developed cognitive level of exposition. The section, therefore, examines neuroeconomic Managerial decision picoeconomics ([Ainslie, 1992](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B1)), which is similarly couched in terms of temporal discounting, as a candidate for the cognitive component of neuro-behavioural decision theory. Although there is a strong fit, however, neuroeconomic Managerial decision picoeconomics provides prescriptions for dealing with the excesses of Managerial behaviour which befit clinical interventions but are not easily implementable in the context of Managerial functioning. In order to overcome this problem, two complementary areas of cognitive-behavioural interaction are examined with a view to increasing understanding of the cognitive component of behaviour and suggesting Managerial prescriptions, especially for team-building. These are RST ([Corr, 2008a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B36)) and Adaption-Innovation Theory of cognitive style ([Kirton, 1976](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B62), [2003](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B63)), both of which rest on neurophysiological bases that overlap with those on which neuro-behavioural decision theory rests and contribute to the cognitive articulation of the MEBDS hypothesis and the suggestion of meliorating action.

Decisions and Cognition discuss the different kinds of management decision and relates them to their possible underlying neurophysiological bases. It also raises the need for clarification of the cognitive dimension of existing theories of neuro-behavioural decision systems and the necessity for Managerial application. Section Competing Decision Systems describes the MEBDS hypothesis in detail and relates it to RST and the relevance to Managerial decision-making of Managers’ temporal horizons. Section Cognitive Dimension introduces in detail the necessity of a cognitive component of the MEBDS hypothesis and the philosophical implications of speaking of cognition. It lays out criteria for a suitable cognitive component including the necessity of a cognitive theory that proceeds at the personal level of exposition, an intentional explanation, and potential integration with the economic bases of MEBDS theory, and a close relationship to the basic disciplines in terms of which the theory is couched. Section The Cognitive Dimension also proposes neuroeconomic Managerial decision picoeconomics ([Ainslie, 1992](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B1)) as a suitable basis for the cognitive component of neuro-behavioural decision theory and evaluates it in terms of these criteria.

The question of appropriate prescriptions for Managerial management is raised in Managerial Organisation-Level Strategies for Changing Managerial Behaviour. Although neuroeconomic Managerial decision picoeconomics provide insight into the nature of dysfunctional decision-making, its prescriptions are couched in clinical terms and are directed towards the amelioration of addictive behaviour. The section turns, therefore, to the conceptualization of Managerial behaviour in terms of adaptive-innovative cognitive style ([Kirton, 2003](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B63)) which has broadly similar neurophysiologic foundations but which comes equipped with clearer implications for Managerial team-building and management. The theory also has implications which are discussed for the understanding of commonplace terms such as strategy, innovation and structure. Overall, the integration of neuro-behavioural decision systems with neuroeconomic Managerial decision picoeconomics, RST and adaptive-innovative cognitive style suggests a theory of Managerial behaviour in Managerial Organisations which comprehends and proposes means of overcoming problems of dysfunction due to inappropriate temporal horizons ([Foxall, 2010](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B50)).

Some Managerial behaviours patently fail to achieve the goals of the Managerial Organisation in which they are performed, leading often to the downfall of the Managers who are responsible for them and sometimes to the failure of the entire Managerial Organisation in which the arise. The hasty shredding of documents of forensic significance, for instance, which has recently figured in more than one dramatic wind-up of a corporation is maladaptive not only for the stakeholders but for the firm itself as a continuing legal entity. For the Managers employed by the Managerial Organisation, whether or not they were involved in the termination with extreme prejudice of the documents involved, the maladaptive actions of a few may mean at the very least the interruption of careers. The apparent greed and excessive seeking of immediate reward that accompanied and partially caused the financial crisis of 2008 provides another graphic illustration of the catastrophic effects of maladaptive Managerial behaviour ([Wargo et al., 2010a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B104)). This extreme form of maladaptive Managerial behaviour illustrates vividly the immediacy that motivates some actions within Managerial Organisations ([Peterson, 2007](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B76)). The informed planning of long-term business operations, in the absence of intrusions caused by short-term concerns, and the timely implementation of strategic intentions, represent the opposite extreme.

It is most probable that neither of these scenarios will figure in the careers of most Managers but temporal horizons nevertheless are the hallmark of most Managerial activities. Some are most accurately characterized as impulsive; others as planned. This categorization does not correspond exactly to the idea of functional decisions on the one hand, those that meet the goals of the Managerial Organisation and its members, versus dysfunction decisions on the other, those that have outcomes that are contrary to such goals. But it seems reasonable to argue that the majority of impulsive decisions have some dysfunctional consequences, while the majority of planned decisions are functional in the sense defined. It is not helpful to write off the dysfunctional behaviour as simply ‘irrational’: it has its own logic and we should seek its causes just as we seek those of its antithesis. A unified neuroscientific framework within which to pursue these ends is required. First, however, it is necessary to define more closely the range of decisions with which we are concerned.

Two classifications of decisions have proved remarkably resilient and are particularly relevant to the present debate because they are closely related to temporal horizons: administrative, operating and strategic decisions ([Ansoff, 1965](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B3)) and [Simon’s (1965)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B94) distinction between programmed and non-programmed decisions. Administrative decisions tend to be routine and to have short time frames. Strategic decisions are, by contrast, long-term and concern the product-market scope of the enterprise, which involves such considerations as diversification policy, the definition of the business, the nature of customer behaviour now and in the future, and the integration of the key business areas, namely marketing and innovation ([Drucker, 2007](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B44)). Operating decisions are derived from strategic decisions that have been taken and entail the implementation not only of current interfaces with the business environment, such as the management of marketing mixes, but also the implementation and management of appropriate administrative practices. Programmed decisions are those that are sufficiently routine to have attracted tried and tested, rule-of-thumb decisions systems; so predictable and delegable are these matters that some authorities question whether they entail decision-making at all. Non-programmed decisions are those that arise de novo in the wake of required responses to unstructured situations: new governmental regulations, novel market requirements, radical changes in a competitor’s behaviour, and so on. These are generally top-management responsibilities.

Although it is true that most administrative decisions are well-programmed, most strategic decisions non-programmed, and operating decisions a mixture of the two, there are programmed and non-programmed aspects of all three types of decision identified by Ansoff. The key question is what level of management is likely to be involved in each decision type. By and large, administrative decisions can be delegated and taken therefore by relatively junior Managers. The repetitiveness that characterizes them suggests that they entail a limited temporal purview which recurs each time they are taken. Indeed, given the extent to which they can be programmed, it is arguable that they are not decisions at all. Strategic decisions are almost by definition unprogrammable and are the domain of senior Managers responsible for the overall policy, strategic scope and strategic direction of the enterprise. These decisions, which entail very long-term perspectives on how the firm will develop, are almost by definition made in a context of uncertainty. They of course have implications for the administrative and operating decisions that flow from them. Operating decisions are typically the province of middle Managers. Although they refer to a time period when relatively accurate assumptions can be made about the product and factor markets in which the firm operates, they are subject to unpredictable fluctuations, e.g., in the behaviour of competitors, which necessitate one-off tactical decisions. The temporal horizons of such decisions may vary from the immediate future to short market cycles.

Another way of looking at these decisions is that administrative and to a large extent operating decisions have a pre-existing framework of conceptualization and analysis within which they can be resolved as they arise; in the case of genuinely strategic decisions, it is necessary to construct such a framework co-terminously with the initial decision process. It also has to be recognized that once strategic decisions have been made and a suitable decision framework established, the Managerial work involved in such decisions takes on an increasingly routine aspect. It is a myth to think that strategic decision-making involves a root and branch analysis of opportunities and capabilities with each planning cycle: many strategic decisions are made recurrently with only small changes in Managerial outlook involved on each occasion. This is of course, given the changing market, technological and competitive environments that are the context of such decisions, a source of danger if the firm fails to monitor its strategic space.

From the point of view of the Managerial Organisation, the overall object with respect to decision-making will be to reach an acceptable balance among administrative, operating, and strategic decision-making so that each kind of decision is made in a timely manner and coordinated with the taking of the other kinds of decision. This state of affairs will ensure that conflict between short-term and long-term Managerial goals is minimised. Most analyses of Managerial decision-making take this purview. But the social cognitive neuroscience approach to Managerial behaviour makes it possible to discuss the tensions arising within individual Managers’ behaviour patterns that make them more or less suited to undertake the decision tasks we have identified. This does not of course mean anything so simplistic as that there are some Managers who are predisposed by their limbic systems to make programmed decisions while others have a propensity to make strategic decisions because of their advanced executive functions (EFs). But what the explanation of Managerial behaviour in terms of the MEBDS hypothesis ([Bickel et al., 2012b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B26)) has in common with work on extreme behaviours like addiction, etc., is a willingness to embrace the idea that Managers’ activities reflect the degree of balance shown by their impulsive and executive systems especially when hypoactivity of the latter permits hyperactivity of the former. It is to this hypothesis that we now turn.

Competing Neuro-Behavioural Decision Systems: The neuroscientific and especially the neuroeconomic explanation of Managerial behaviour in Managerial Organisations has often concentrated on such matters as trust ([Zak, 2004](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B107),[2007](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B108); [Zak and Nadler, 2010](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B109)), cooperation and conflict ([Levine, 2007](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B69); [Tabibnia and Lieberman, 2007](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B99)), reward processing ([Wargo et al., 2010b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B105)); and social interaction (Caldú and Dreher, 2007). However, this section seeks an additional explanation for these behaviours in the competing impulsive and executive decision systems associated with the operations of separate, though related, brain regions in the context of corporate problem solving. These neural areas are also associated with differences of temporal horizon, emotional response to circumstances and the cognitive control of behaviour. Much of the work inspired by the MEBDS hypothesis involves addictive behaviour, influenced by activity located at the impulsive end of the neural spectrum, in contrast to the more calculated behaviour that is associated with the EFs, located towards the other pole, which manifest in planning, foresight and evaluation ([Bickel et al., 2006](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B23), [2012b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B26)). Each neural decision system generates its own rewards, relatively immediate and strongly-emotional in the case of the impulsive system, relatively long-term, considered and cognitive in the case of the executive system ([Moll and Grafman, 2011](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B75)). Could it be that the explanation of maladaptive and adaptive Managerial decision-making is to be found in the operation of these systems too?

The suspicion that MEBDS might be implicated in Managers’ maladaptive behaviours is especially significant in the case of small entrepreneurial businesses which rely largely on the endeavour s of a single prime-mover. That person’s tendency towards either impulsiveness or self-control is likely to be a dominant influence on the effectiveness of the enterprise. A tendency towards impulsiveness is likely to manifest in unplanned responses to momentarily appearing opportunities which are implemented without consideration of the long-term consequences for the firm. Unless such instant reactions are constrained by the exercise of EFs which engender planning, foresight, weighing of the relevant consequences, the balance required to build and maintain a successful Managerial Organisation is unlikely to be forthcoming. Conversely, an exaggerated emphasis on strategic thinking and planning which does not express itself in action to launch business ventures will stymie enterprise. The possibility of imbalance arises in a different manner in the large-scale Managerial Organisation. Large firms face similar imperatives requiring the coordination of strategic planning and operational decision-making but the coordination is considerably more complex since different Managers are responsible for these tasks. Complications arise because Managers charged with making administrative and operational decisions may show cognitive and Managerial styles that are incompatible with those of Managers charged with strategic planning.

The clearest operational measure of balance/imbalance between the neural systems is the extent of temporal discounting apparent in the Manager’s behaviour ([Bickel and Yi, 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B28); see also [Baumesiter and Tierney, 2011](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B9)). The Managerial Organisation-level goal of achieving and maintaining balance among administrative decisions which are predominantly programmed in Simon’s sense, strategic decisions which are relatively unprogrammed, and operating decisions which are predominantly programmed, but sometimes contain unprogrammed elements, has to be accomplished through Managers who are typically responsible for a single kind of decision but who bring a particular personal time horizon to it. While the avoidance of conflict between short-term and long-term objectives is a Managerial goal, it is not necessarily within the competence or interests of individual Managers. The MEBDS hypothesis per se has not previously been applied to Managerial concerns. However, the distinction it makes between the functioning of an impulsive system based on the limbic and paralimbic systems and an executive system based on the prefrontal cortex (PFC), together with the possibility that an imbalance between the operations of the two systems may lead to dysfunctional behaviour, is strongly represented in the emerging literature of the neuroeconomics of Managerial Organisations (e.g., [Senior and Butler, 2007a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B91),[b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B92); [Stanton et al., 2010](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B97)). What we may refer to as neuro-behavioural decision theory, which includes the MEBDS hypothesis, other models such as the Somatic Marker hypothesis ([Damasio, 1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B37)), and the application of similar thinking in management (e.g., [Wargo et al., 2010a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B104)), appears to be emerging as a research paradigm within which to understand dysfunctional behaviour ([Klein and D’Esposito, 2007](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B64); [Michl and Taing, 2010](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B73)).

The first purpose of this section is to examine and suggest a solution to a conceptual problem that arises in these analyses, a solution which may have a bearing on the kinds of problem of dysfunctional management mentioned above. Like the MEBDS model itself, the debate of competing neural systems in the context of Managerial management tends to conflate events taking place at the neurophysiological level with the cognitive processes ascribed in order to explain and interpret behaviour. We are often assured, for instance, that this part of the brain ‘evaluates’, ‘plans’, or ‘decides’. These terms all describe cognitive operations that belong at a level of exposition that refers to the person as a whole rather than the sub-personal level of neurobiology. Each level is properly described in its own language that obeys particular rules and which points to a separate kind of explanation. To draw this distinction between levels of exposition is not to make ontological distinctions or to invite a dualistic approach: it is simply to make clear that we must speak in quite different ways of the rate of firing of neurons from those we employ in speaking of the way in which a consumer evaluates alternative brands. The argument is that while ontologically we have nothing to work with but material events, in explanationing for behaviour we need to maintain the distinction between what is happening at the sub-personal level of exposition and how we explanation for behaviour at the personal level.

Part of the difficulty arises from a failure to delineate a cognitive component of neuro-behavioural decision theory and to show how it is related to the sub-personal level of neurophysiological events and the super-personal level of behavioural reinforcement. This section proposes that Neuroeconomic Managerial decision picoeconomics ([Ainslie, 1992](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B1)), which analyses the interaction of motivational states that refer to competing temporal horizons, provides the necessary cognitive level of exposition. If this incorporation of neuroeconomic Managerial decision picoeconomics as a cognitive level of exposition for neuro-behavioural decision theory is successful, it suggests a means of overcoming problems of dysfunctional Managerial behaviour that are due to hyperactivity of the impulsive system aided and abetted by hyperactivity of the executive system.

The kind of extreme decision-making involved in corporate fraud or the reckless investing that brings whole economic systems low is comparatively rare. In any case, while neurophysiologic processes can explain the behaviour of individual participants in such dramas, the opportunity so to act and the far-reaching consequences of such decision-making are likely to be determined by structural factors and special events that lie perhaps beyond the immediate purview, and certainly beyond the control, of the decision-makers themselves ([Bailey, 2007](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B4); [Yeats and Yeats, 2007](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B106)). An important focus of this section is on understanding better the nature of decision-making by Managers who are, by comparison, involved in more day-to-day corporate management. The decisions that Managers are required to make vary in terms of the cognitive level they demand, including level of intelligence and capacity to cope with complexity. They differ also in terms of their paradigmatic context: at the extremes, some decisions are solvable within the framework of assumption, behavioural norms and market structure that has prevailed hitherto while others require that assumption, behaviours, structures and other variables be reconceptualized and perhaps even re-created. We cannot take all of these factors into consideration but we can speak in terms of the decision styles of Managers which have a bearing on their likelihood of success in tackling the various kinds of decision with which they are confronted. Our task is to understand better the causal fabric of the environment within which Managers operate (the ‘super-personal level of exposition’) and the influence of neurophysiology on their behaviours (the ‘sub-personal level’).

The section next examines the MEBDS thesis in greater depth, relating it as appropriate to Managerial behaviour and concerns (Section Competing Decision Systems). This is a prelude to its discussing the cognitive requirements of the model and evaluate neuroeconomic Managerial decision picoeconomics as its cognitive component (Section The Cognitive Dimension). Once that is achieved, it is possible to consider the application of the insights of neuroeconomic Managerial decision picoeconomics and adaption—innovation theory in addressing problems of Managerial dysfunction and the research agenda that emerge from these approaches (Section Managerial Organisation-Level Strategies for Changing Managerial Behaviour).

MEBDS hypothesis rests on the somewhat simplifying assumption that a ‘limbic system’ can be coherently identified which is differentially implicated in emotional responding and that a cortical area, differentially implicated in judgment, planning and other cognitive activities, can also be identified. Although the reality is undoubtedly more complicated than this—neural activations are seldom exclusive to one part of the brain—the dichotomy is retained here for ease of exposition with regard to the MEBDS hypothesis and for the sake of continuity with a wider literature (cf. however [Lawrence and Calder (2004)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B66) with [Ross (2012)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B84)). Bickel’s hypothesis suggests that the degree of addictiveness exhibited in behaviour reflects the balance of activity in these two broadly defined brain regions, the first of which, based on the amygdala and ventral striatum, involves the distribution of dopamine (DA) during reinforcement learning, while the second, residing in the PFC, is implicated in the evaluation of rewards and their outcomes ([Walton et al., 2011](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B103); see also [Dayan, 2012](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B40); [Symmonds and Dolan, 2012](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B98)).

The impulsive system inheres in the amygdala and ventral striatum, a midbrain region concerned with the valence of immediate results of action, and is liable to become hyperactive as a result of ‘exaggerated processing of the incentive value of substance-related cues’ ([Bechara, 2005](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B10), p. 1459; see also [Delgado and Tricomi, 2011](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B41)). Drug-induced behaviours correlate with enhanced response in this region when the amygdala displays increased sensitization to reward ([London et al., 2000](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B70);[Bickel and Yi, 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full" \l "B28)). The executive system, located in the PFC is normally associated with planning and foresight but is hypothesized to become hypoactive in the event of addiction; the absence of its moderating function is responsible for the exacerbation of the effects of the hyperactive dopaminergic reward pathway; this imbalance is then viewed as the cause of dysfunctional behaviour ([Bickel et al., 2011b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B24), [2013](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B19)). In summary, the MEBDS hypothesis posits that drug seeking results from ‘amplified incentive value bestowed on drugs and drug-related cues (via reward processing by the amygdala) and impaired ability to inhibit behaviour (due to frontal cortical dysfunction)’ ([Bickel and Yi, 2010](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B18), p. 2; see also [Jentsch and Taylor, 1999](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B111); [Rolls, 2009](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B83)).

Before considering the MEBDS hypothesis, it is useful to note [Damasio’s (1994)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B37) Somatic Marker hypothesis which bases a model of decision-making systems on similar neurophysiological foundations but emphasizes the role of emotion and feelings, downplaying economic considerations. Decision-making reflects the Marker signals laid down in bioregulatory systems by conscious and non-conscious emotion and feeling; hence, Bechara and Damasio ([2005](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B12); see also [Bechara et al., 2000](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B13)) argue that in dealing with decision-making economic theory ignores emotion. Economics is exclusively concerned with ‘rational Bayesian maximization of expected utility, as if humans were equipped with unlimited knowledge, time, and information processing power’. They point, by contrast, to neural evidence which shows that ‘sound and rational’ decision-making requires antecedent accurate emotional processing ([Bechara and Damasio, 2005](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B12), p. 336; see also [Phelps and Sokol-Hessner, 2012](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B77)).

Damasio’s ([1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B37)) hypothesis is the outcome of brain lesion studies in which damage to the ventromedial prefrontal cortex (vmPFC) was found to be associated with behaving in ways that were personally harmful, especially insofar as they contributed to injury to the social and financial status of the individual and to their social relationships. Although many aspects of these patients’ intellectual functioning such as long-term memory were unimpaired, they were notably disadvantaged with respect to learning from experience and responding appropriately to emotional situations. Moreover, their general emotional level was described as ‘flat’. Damasio’s observation on these findings was that ‘the primary dysfunction of patients with vmPFC damage was an inability to use emotions in decision making, particularly decision making in the personal, financial and moral realms’ ([Naqvi et al., 2006](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B112), p. 261). Thus was born the central assumption of the Somatic Marker hypothesis that ‘emotions play a role in guiding decisions, especially in situations in which the outcomes of one’s decisions, in terms of reward and punishment, are uncertain’ (ib.; see also [Bechara, 2011](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B11)). Of relevance here is the finding that the vmPFC may be implicated in activity of the parasympathetic nervous system (PNS), which in contrast to the sympathetic nervous system (SNS) is involved in the explorative monitoring of the environment and the discovery of novelty ([Eisenberger and Cole, 2012](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B113)). This is corroborative of both Damasio’s view and the nature and behaviour of the innovative Manager discussed below.

Inherent in the Somatic Marker hypothesis is the attempt to describe not only the separate functions of the brain regions involved in emotional processing but also the interconnections between them ([Haber, 2009](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B58)). The starting point is operant behaviour, particularly the mechanisms of reinforcement learning ([Daw, 2013](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B38); [Daw and Tobler, 2013](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B39)). Specific behaviours eventuate in rewards as a result of which the amygdala triggers emotional/bodily states. These states are then associated via a learning process to the behaviours that brought them about by means of mental representations. As each behavioural alternative is subsequently deliberated upon in the course of decision-making, the Somatic state corresponding to it is re-enacted by the vmPFC. After being brought to mind in the course of decision-making the Somatic states are represented in the brain by sensory processes in two ways. First, emotional states are related to cortical activation (e.g., insular cortex) in the form of conscious ’gut feelings’ of desire or aversion that are mentally attributed to the behavioural options as they are considered. Secondly, there is an unconsciousmapping of the Somatic states at the subcortical level—e.g., in the mesolimbic dopaminergic system; in this case, individuals choose the more beneficial option without knowingly feeling the desire for it or the aversiveness of a less beneficial alternative ([Ross et al., 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B85); see also [Di Chiara, 2002](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B43); [Robbins and Everitt, 2002](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B80);[Tobler and Kobayashi, 2009](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B100)).

The rapidity with which the impulsive system acts in propelling behaviour is underlined by [Rolls’s (2005)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B81) theory of emotion in which the reinforcing stimuli consequent on a behavioural act as conditioned stimuli that elicit emotion feelings. The automaticity of this interaction of operant and Pavlovian conditioning may explanation for behaviour in two ways. The emotion feeling may function as an internal discriminative stimulus to increase the probability of the behaviour that produced it being reprised; it is equally likely that the emotion feeling is the ultimate reward of the behaviour in question and that, by definition, it performs a reinforcing role ([Foxall, 2011](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B51)). Either way, the effects of basic emotions on subsequent responding is immediate and uninfluenced by reflection at the cognitive level. While the criticism of economics shown by the authors of the Somatic Marker hypothesis appears to rule an economic orientation out of their purview, the MEBDS approach actively builds on insights from operant behavioural economics ([Bickel et al., 1999](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B27), [2010](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B22), [2011a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B20),[b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B24); [Bickel and Vuchinich, 2000](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B17); [Bickel and Marsch, 2001](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B16); [Bickel and Johnson, 2003](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B15)).

While the Somatic Marker hypothesis relied in its inaugural stages on lesion studies, the central research technique of cognitive neuropsychology, the work of [Rolls (2005)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B81) offers confirmation of the role of operant behaviour in the emerging paradigm. Recording single neurons’ activity levels, [Rolls (2005](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B81), [2008)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B82) reports that vmPFC neurons respond to the receipt of primary reinforcers such as pleasant-tasting foods. The integrity of the conditioning paradigm is evinced by the finding that devaluation of the reinforcer, for example through satiety, reduced the responses of such areas to these primary reinforcers. fMRI studies also offer corroboration.[Gottfried et al. (2003)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B55) report that when a predicted primary reinforcer is devalued then vmPFC activity engendered by that reinforcer is reduced. Hence, the vmPFC contributes to the prediction of the reward values of alternative behaviours by reference to their capacity to generate rewarding consequences in prior occasions.[Schoenbaum et al. (2003)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B86) used lesion and physiological studies to show that this capacity to encode predictive reward value depends on an intact amygdala.

The MEBDS model differs in emphasis from Damasio’s Somatic Marker hypothesis. Their underlying similarity inheres in an acknowledgement that separate functions are performed within the overall impulsive-executive system. But Bickel draws attention to the interconnected operations of the impulsive system and the executive system in the production of behaviour ([Bickel et al., 2007](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B25)). The MEBDS hypothesis is open, moreover, to the incorporation of economic analysis in the form of behavioural economics and neuroeconomics ([Bickel et al., 2011a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B20)). Impulsive action, defined as the decision of a smaller but sooner reward (SSR) over a larger but later reward (LLR), is certainly associated with the over- activation of the older limbic and paralimbic areas, while the valuation and planning of future events and outcomes engages the relatively new (in evolutionary terms) PFC. However, it is the interaction of these areas, which are densely inter-meshed, that generates overt behaviours. The MEBDS hypothesis thus stresses the continuity of the components of the neurophysiologically-based decision system and Bickel’s conception is therefore one of a continuum on which the impulsive and executive systems are arrayed theoretically as polar opponents ([Porcelli and Delgado, 2009](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B79)).

Specifically, [Bickel et al. (2012a)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21) identify, in addition to trait impulsivity, four kinds of state impulsivity: behavioural disinhibition, attentional deficit impulsivity, reflection impulsivity and impulsive decision. Trait impulsivity is associated with mesolimbic OFC and correlates with medial PFC, pregenual anterior cingulate cortex (ACC) and ventrolateral PFC; venturesomeness (sensation-seeking) correlates with right lateral orbitofrontal cortex, subgenual anterior cingualate cortex, and left caudate nucleus activations. The concept of trait impulsivity recognizes behavioural regularities that are cross-situationally resilient. Within this broad construct, sensation-seeking or venturesomeness is widely known to be related to a need to reach an optimum stimulation level. [Bickel et al. (2012a)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21) associate it with sensitivity to reinforcement, the theory of which has been extensively developed by [Corr (2008b)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B35) and is discussed in greater detail below. Of the four state impulsivities discussed by [Bickel et al. (2012a)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21), behavioural disinhibition is associated with deficiencies in the anterior cingulate and prefrontal cortices, attentional deficit impulsivity with impairments of caudate nuclei, ACC, and parietal cortical structures, and with strong activity in insular cortex; reflection impulsivity with impaired frontal lobe function; and impulsive decision with increased activation in limbic and paralimbic regions in the course of the selection of immediate rewards.

This latter is again strongly predicted by RST ([McNaughton and Corr, 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B114)). It is debatable whether the state impulsivities mentioned here are anything other than the behavioural manifestations of trait impulsivity in particular contexts. The four state impulsivities that [Bickel et al. (2012a)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21) note are probably outcomes of a general tendency to act impulsively from which they are predictable. Behavioural disinhibition is the inability to arrest a pattern of behaviour once it has started; it is also evinced in acting prematurely with deleterious outcomes. Attentional deficit impulsivity is failure to concentrate, to persevere with salient stimuli. Again, the outcome is the adoption of risky behavioural modes with poor consequences. Reflection impulsivity is failure to gather sufficient information before deciding and acting; inability to get an adequate measure of the situation leads to unrewarding behaviours. Impulsive decision is a behavioural preference for a SSR over a LLR for which the individual must wait. All of these state impulsivities are actually behaviours, the outcomes of trait impulsivity. More relevant to the present debate ispreference reversal in which a longer-term, more advantageous goal is preferred (e.g., verbally) at the outset only to decline dramatically in relative value as the delivery of the earlier less advantageous reward becomes imminent.

[Bickel et al. (2012a)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21) define EFs as ‘behaviour that is self-directed toward altering future outcomes’ (p. 363; see also [Barkley, 2012](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B6)) and point out that EFs are consensually associated with activity in the PFC. PFC is generally recognized as implicated in the integration of motivational information and subsequent decision-making ([Wantanabe, 2009](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B115)), exerting a supervisory function that governs the regulation of behaviour ([Bickel et al., 2012a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21)); hence, [Bickel et al. (2012a)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21) point out, its designation as a supervisory attentional system (SAS; [Shallice and Cooper, 2011](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B93)). While some authors emphasize a single element of EFs such as the attentional control of behaviour or working memory or inhibition, others stress groups of elements: planning, working memory, attentional shifting or valuing future events, emotional aspects of decision-making. Addiction can then be viewed as a breakdown in the operations of the EFs or as impaired response inhibition leading to the increased salience of addiction-orientated cues. [Bickel et al. (2012a)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21) concentrate on Attention, Behavioural flexibility, Planning, Working memory, Emotional activation and self regulation (EASR) which they group into three major categories: (1) the cross-temporal Managerial Organisation of behaviour (CTOB) which is concerned with the awareness of the future consequences of current or contemplated behaviour and therefore with planning for events that will occur later; (2) EASR which involves the processing of emotion-related information and ‘initiating and maintaining goal-related responding’; and (3) metacognition which includes social cognition and insight, empathy, and theory of mind (ToM).

The CTOB comprises attention (closely related to dorsolateral prefrontal cortex (DLPFC), behavioural flexibility (frontal gyrus activity; lesioning of PFC is well-known to be associated with the diminution of behavioural flexibility ([Damasio, 1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B37); [Bechara, 2011](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B11)), behavioural inhibition (right inferior frontal cortex and insula are activated during behavioural inhibition which is also associated with reduced activity in left DLPFC, the right frontal gyrus, right medial gyrus, left cingulate, left putamen, medial temporal, and inferior parietal cortex), planning (in which DLPFC the VMPFC, parietal cortex, and striatum are implicated), valuing future events(in the case of previewing and selecting immediate rewards: limbic and paralimbic regions; in the case of long-term decisions: prefrontal regions; see [McClure et al., 2004](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B71)); and working memory (DLPFC, VMPFC, dorsal cingulate, frontal poles, medial inferior parietal cortex, frontal gyrus, medial frontal gyrus, and precentral gyrus; [Bickel et al., 2012a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21), pp. 363–367).EASR concerned with the management of emotional responses is implemented in Medial PFC, lateral PFC, ACC, OFC. Metacognitive processes (MP) involve recognition of one’s own motivation and that of others which is implemented in the case of insight or self-awareness by the insula and ACC, and in the case of social cognition by medial PFC, right superior temporal gyrus, left temporal parietal junction, left somatosensory cortex, right DLPFC; moreover, impaired social cognition follows lesions to VMPFC ([Damasio, 1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B37); [Bechara, 2005](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B10); [Bickel et al., 2012a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21), pp. 367–368).

RST ([Gray, 1982](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B56); [Corr, 2008b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B35); [Smillie, 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B96)) includes the excitatory (impulsivity) and inhibition (executive) components of the MEBDS model but also permits us to make extensions relating to the expected behaviour patterns that follow from each and the way in which individual differences can be summed up in terms of an ascription of personality types.[1](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#note1) RST proposes that the basic behavioural processes of approach and avoidance are differentially associated with reinforcement and punishment and that individuals show variations in their sensitivity to these stimuli.[2](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#note2)

Approach is behaviour under the control of positively reinforcing or appetitive stimuli and is mediated by neurophysiological reward circuitry that the theory categorizes as a Behavioural Approach System or BAS. The BAS consists in the basal ganglia, especially in the mesolimbic dopaminergic system that projects from the ventral tegmental area (VTA) to the ventral striatum (notably the nucleus accumbens) and mesocortical DA PFC ([Smillie, 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B96); cf. [Pickering and Smillie, 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B78)). For recent debate of the role of the striatum in decision-making and the processing of rewards, see [Delgado and Tricomi (2011)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B41). Recent research demonstrating the role of this dopaminergic system in formulating ‘reward prediction errors’ is consonant with this understanding. Unpredicted reward is followed by increase in phasic dopaminergic activity whereas unpredicted non-reward is followed by a decrease and unchanged when reward is entirely predicted ([Schultz, 2000](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B87), [2002](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B88);[Schultz and Dickinson, 2000](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B89); [Schultz et al., 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B90)). Unpredicted reward instantiates the activity of the BAS, therefore, and predicted reward maintains its operation. Moreover, BAS activity increases positive reward (pleasure) and motivates approach to reinforcing stimuli and stimuli that predict reinforcement. Such approach is characteristic of the extraverted personality; [Corr (2008b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B35), p. 10) sums up the personality type as ‘optimism, reward-orientation and impulsivity’ and notes that it maps clinically on to addictive behaviours.

These emotional and motivational outcomes represent one pole of a continuum of individual differences that manifest differential BAS and Behavioural Inhibition System (BIS) reactions to stimuli. There is a corresponding though antithetical explanation of avoidance in RST. Avoidance is shaped by sensitivity to stimuli of punishment and threat and mediated by two bio-behaviourally based systems of emotion and motivation. The first of these, the Fight-Flight-Freeze system (FFFS), is triggered by aversive stimuli and the resulting feeling of fear, what [Corr (2008b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B35), p. 10) refers to as the ‘get me out of here emotion’; the FFFS’s motivational output is a behaviour pattern characterized as ‘defensive avoidance’. However, if the consequential stimuli involved are mixed in terms of their emotional valence then the BIS, which is involved generally in the resolution of goal-conflict is activated; in this case, the emotional output is anxiety, the ‘watch out for danger’ emotion [Corr (2008b, p. 11)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B35) and the behavioural outputs are risk evaluation and cautiousness which are described as manifesting defensive approach. Hence, in summary, reward sensitivity leads to positive emotion and approach and a response pattern that is characterized as ‘extraversion’ via behavioural observation or psychometric testing; by contrast, punishment sensitivity leads to negative emotion and avoidance and a personality characterized in terms of neuroticism ([Smillie, 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B96)).

RST also relates the FFFS and BIS to specific neurophysiological systems. In the case of the FFFS this is the periaquedital gray, which is implicated in acute or proximal threat, and the medial hypothalamus, amygdala and interia cingulate cortex, implicated in distal threats. The BIS comprises the septo-hippocampal system and the amygdala. The emotional output of the FFFS is fearfulness while that of the BIS is anxiety. In either case, the emotional outputs are negative and most forms of RST relate this to neuroticism. The value of employing explanatory constructs referring to personality types such as extraversion and neuroticism is that they summaries individual differences in reinforcement sensitivity, adding both to the interpretation of behaviour and to its prediction in novel environments.

**Temporal Horizon:** Dysfunctional behaviours are those dominated by either the impulsive system or the executive system. The impulsive system evolved because it was evolutionarily-adaptive as far as inclusive fitness was concerned. Its preoccupation with short-term goals and its immediate response to opportunities ensured its contribution to survival of the individual and thereby to its biological fitness. It is closely related to the kinds of modular functioning posited by [Fodor (1983)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B46) which allows rapid responses to environmental concerns. It is closely related also to the emotion-feelings associated with such response capacity, pleasure in particular but also arousal and dominance. These are the ultimate rewards of instrumentally conditioned behaviour ([Rolls, 2008](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B82); [Foxall, 2011](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B51)).

When we speak of the dysfunctional consequences of a hyperactive impulsive system in seeking to understand and explain a Manager’s behavioural repertoire we are referring to hyperactivity in these emotional-reward systems which leads, for instance, to preoccupation with short-term goals at the expense of undertaking longer-term planning, the reckless taking of investment decisions promising rapid high returns and a consequent over-cautiousness, and an unwillingness to invest in future. Another manifestation is rigidity in the pursuit of a previously selected goal even though the environment has changed and flexibility is called for. We are also suggesting that it is unlikely that this impulsive-hyperactivity occurs in isolation from hypoactivity of the executive system. Hence, imbalance occurs because Managers place disproportionate importance on the emotional highs resulting from activities that result in immediate or near-immediate reinforcement at the expense of the pursuit of considered action that would be under the control of the executive system. Moreover, both utilitarian reinforcement and informational reinforcement are engendered which brings about high levels of pleasure and arousal, and in a context that permits the emotion-feeling of high dominance ([Kringelbach, 2010](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B65);[Foxall, 2011](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full" \l "B51)). This is probably the strongest combinations of interacting reinforcement for the maintenance of Managerial behaviour. From the Managerial Organisation’s point of view, if this behavioural style becomes characteristic of a function, department or even of the firm as a whole, the outcome will be an overconcentration on administrative and operational activities at the expense of a strategic perspective which embraces and anticipates the opportunities and threats of the changing market-competitive environment.

However, dysfunctional behaviour may also result from hypoactivity of the impulsive system and hyperactivity of the executive system ([Mojzisch and Schultz-Hardt, 2007](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B74)). The intellectual rewards of a preoccupation with long-term planning, obtaining and analysing information, mulling over strategic possibilities, may lead to a lack of strategic implementation so that the short-term decisions necessary for the day-to-day operations of the firm are neglected, working capital is lacking, the firm cannot continue. The pleasures and arousal resulting from cognitive activity and the feeling of dominance that this provides can manifest in Managerial sclerosis which over-values intellectual engagement with Marker structures, competition and, especially, the strategic scope of the Managerial Organisation. From the Managerial Organisation’s viewpoint, if this behavioural style becomes widespread, there will be an imbalance in favour of strategic planning and decision-making at the expense of the day-to-day imperatives of the firm’s response to the tactical behaviour of competitors and the vagaries of consumer decision. The executive system also evolved because it favoured biological fitness. Its operation is much like that of the central cognitive function posited by [Fodor (1983)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B46).

In view of the importance of avoiding a general tendency towards either kind of imbalance in the behaviour of the firm, it might be argued that our unit of analysis should be the Managerial Organisation as a whole since it is presumably structural elements in the Managerial Organisation’s culture that require attention if the problem is to be overcome. This is undeniably correct but our present objective is less to overcome problems of imbalance, which are anyway the subject of innumerable management texts, and more to understand how individual Managers may be prone to one or other behavioural style. The central factor involved in diagnosing either extreme at the individual level is the temporal horizon of the Manager since this correlates highly with the influence of the impulsive and/or executive systems. This is best considered, however, after the way in which cognitive language is used in neuro-behavioural decision theory, which brings further understanding of the role of temporal horizon in decision-making. It also suggests a means of overcoming problems of impulsive-hyperactivity and executive-hypoactivity at the individual level which must be evaluated before an Managerial Organisation-level solution can be proposed and appraised.

Neuroscience and behavioural science employ extensional language, the third-personal mode which is taken as the hallmark of science ([Dennett, 1969](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B42)). The truth value of extensional sentences is preserved when co-designative terms are substituted for one another. The phrase, ‘the fourth from the sun’ can be substituted for ‘Mars’ in the sentence ‘That planet is Mars’ without surrendering the truth value of the sentence. However, the truth value of a sentence containing intentional language, such as ‘believes’, ‘desires’ or ‘feels’, is not maintained when co-designatives are substituted. Given the sentence, ‘John believes that that planet is Mars’, we are not at liberty to say, ‘John believes that planet is the fourth from the sun’, since John may not know that Mars is the fourth planet. Intentional sentences have another unique property: the intensional inexistence of their subjects. The truth-value of my saying ‘I am driving to Edinburgh this weekend’, an extensionally-expressed statement, is established by there being a place called Edinburgh to which I can travel. But if I say that I am seeking the golden mountain, looking for the fountain of youth or yearning for absolute truth, none of the entities named in these intentional expressions need actually exist for the truth value of the sentences to be upheld. Finally, it is not possible to translate intentional sentences into extensional ones without altering their meaning. Intentional sentences usually take the form of an ‘attitude’ or verb such as believes, desires or wants followed by a proposition such as ‘that today is Tuesday’ or ‘that eggs are too expensive’; hence, such sentences are known as ‘propositional attitudes’ ([Chisholm, 1957](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B32)). The proposed development of the MEBDS hypothesis involves more than terminological clarification. The principles just described govern not only linguistic usage but also the kinds of theories we invoke in order to explain our subject matter and care must be taken to ensure that each is confined to the level of explanation or interpretation to which it is appropriate. Cognitive terminology is intentional and belongs only at the level of the person ([Bennett and Hacker, 2003](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B14)).

[Dennett (1969)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B42) distinguishes the sub-personal level of explanation, that of ‘brains and neuronal functioning’ from the personal level of explanation, that of ‘Managers and minds’. The sub-personal level thus entails a separate kind of scientific purview and approach to explanation: by encompassing neuronal activity it is the domain of the neuroscientist and leads to an extensional explanation. The personal level which is the domain of mental phenomena is that of the psychologist; it requires an intentional explanation. A third level of explanation is required, however, in order to cover the whole range of phenomena and sciences that deal with them in a comprehensive approach to the explanation of behaviour ([Foxall, 2004](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B47)). This is the super-personal level of explanation which encompasses operancy,[3](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full" \l "note3) the respect in which the rate of behaviour is contingent upon its reinforcing and punishing consequences; this is the field of extensional behavioural science.

Care is necessary to maintain the separation of these three levels since the mode of explanation which each entails is unique and cannot be combined with the others in a simple fashion. The fundamental difference in mode of explanation which must be constantly recognized is as follows. The sub- and super-personal levels, which are based on the neuro- and behavioural-sciences respectively, require the use of extensional language and explanation. Both of which are in principle amenable to experimental (‘causal’) analysis, or failing this to the quasi-causal analysis made possible by statistical inference. They differ from one another in terms of the kind of stimuli and responses (independent and dependent variables) that must be taken into consideration in empirical testing of the hypotheses to which they give rise. They differ more fundamentally from the personal level of explanation, which attracts a wholly different mode of analysis, namely that of intentional psychology; the approach to explanation in this case relies on the ascription of beliefs, desires and feelings on the basis of non-causal criteria.

The proposed development of the MEBDS hypothesis involves more than terminological clarification. The principles just described govern not only linguistic usage but also the kinds of theories we invoke in order to explain our subject matter and care must be taken to ensure that each is confined to the level of explanation or interpretation to which it is appropriate. Cognitive terminology is intentional and belongs only at the level of the person ([Bennett and Hacker, 2003](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B14)). The critique of the MEBDS hypothesis takes the form therefore of conceptual development. The MEBDS hypothesis is described by Bickel and colleagues in neuroscientific, cognitive and behavioural terms without regard to the domains of explanation to which each of these categories belongs. For example, although they offer what purports to be a behavioural definition of EF, they define several of its component parts in terms that are cognitive. Following [Barkley (1997a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B5),[b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B7)), they define EF as ‘as behaviour that is self- directed toward altering future outcomes’ ([Bickel et al., 2012a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21), p. 363), but they list among those of its elements which suggest ‘CTOB’: attention, planning, valuing future events and working memory. These clearly are or involve cognitive events. Similarly, among the elements that make up ‘emotional and activation self-regulation’, they list: ‘the processing of emotional information’ and ‘initiating and maintaining goal-related responding’. Finally, as elements of ‘MP’ they list: ‘social cognition’ or ‘ToM’ and ‘insight’. [Bickel et al. (2012a)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B21) define impulsivity behaviourally in terms of actions prematurely performed that eventuate in disadvantageous outcomes. They go on, however, to describe impulsivity as consisting in the trait of impulsiveness, a structural personality variable that incorporates sensation-seeking, deficits in attention and reflection impulsivity which is an inability to collect and evaluate information prior to taking a decision. All of these are intensional.

So far we have advocated that behavioural and neuroscientists maintain the appropriate syntax in speaking of intentional concepts such as beliefs and desires as opposed to extensional objects such as neurons and behaviour patterns. This means understanding and maintaining the sub-personal, personal and super-personal levels of exposition and employing only the appropriate language at each level. A more satisfying outcome for neuro-behavioural decision theory would be to incorporate a level of cognitive exposition the content of which complemented the extensional sciences we have discussed. This section sets out the criteria that such an explanation should fulfill; the following section evaluates neuroeconomic Managerial decision picoeconomics ([Ainslie, 1992](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B1)) as that cognitive component.There are four requirements of any candidate for the cognitive component of neuro-behavioural decision theory. It must first be capable of filling the need for a personal level explanation of the causes of behaviour. Second, it must provide an intentional explanation. Third, it should be capable of linking to the behavioural economics and neuroeconomics analyses that are found in the hypothesis. And, finally, it must relate philosophically to broader disciplinary concerns including neurophysiology and operancy.

A cognitive explanation is required to provide understanding of the ways in which individuals subjectively respond to the circumstances which influence their behaviour towards rewards that may have short-term benefits but which entail longer-term deleterious consequences. Being able to characterize what individuals desire and believe in these situations, what they perceive and how they feel, provides an indication of their underlying disposition to respond in a particular way to rewards and punishments occurring at different times. This is of course a highly theoretical enterprise; in order to avoid undue speculation and conjecture, therefore, it is important that the cognitive requirements of neuro-behavioural decision theory are provided by a coherent body of knowledge relating personal level factors to situations that promote consumption. The required personal level exposition must indicate the particular intentional terms that are applicable to the explanation of normal and addictive behaviours within the framework of an overall theory that can systematically relate the two antipodal behaviour patterns. It must also be capable of explaining how intentional entities like beliefs and desires, perceptions and emotions would act upon the impulsion towards fulfillment of immediate wants, such as consumption of an addictive substance, in order to bring about a more advantageous long-term result. This calls for a well-worked out theory of human behaviour over the continuum of normal to addictive behaviours rather than an ad hoc application of intentional language on the basis of rapid observation of an individual’s behaviour.

The MEBDS hypothesis relies heavily on operant behavioural economics and neuroeconomics in order to explain the reinforcer pathologies that underlie addictive patterns of behaviour. It would be advantageous, therefore, for the cognitive component of the model to link to the basic exposition in economic terms. The usefulness of the cognitive explanation might be questioned because of its inherently theoretical nature; this objection can be overcome if its explanation of behaviour can be specified in language that is consonant with the provisions of consumption in the face of extremely high elasticity of demand and temporal discounting of the consequences of behaviour. A broader relationship between the cognitive explanation of behaviour and the underlying neuroscience and behavioural science that comprise the MEBDS hypothesis is necessary that goes beyond economic integration. Although a major point of the present argument is that cognitive explanations differ fundamentally from those provided by the extensional sciences, the intentional component must be consistent with what is known of the neurophysiological basis of addiction and also with its relationship to the reinforcers and punishers that follow behaviour.

[Herrnstein’s (1997)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B59) matching law suggests that the value of a reinforcer is inversely proportional to its delay, i.e., as the delay becomes shorter, the value increases dramatically. This is the essence of hyperbolic discounting. The key difference between exponential and hyperbolic discounting is that in the former the LLR is always preferable to the SSR, regardless of time elapsed, whereas in the latter there is a period during which the SSR is so highly valued (because the time remaining to its possible realization is so short) that it is preferred to the LLR ([Ainslie, 1992](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B1); [Ainslie and Monterosso, 2003](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B2)). This is clearly not because of its objective value which is by definition less than that which can be obtained through patience, but because the time remaining to its possible realization is now so short, that it is preferred to the later but larger reward. Ainslie notes that these findings harmonize with Freud’s observations that an infant behaves as if expecting immediate gratification but becomes, with experience, willing to wait for the longer-term alternative. In other words, still paraphrasing Freud, if the pleasure principle is resisted, the outcome will be the exercise of the reality principle. In the terminology of behavioural psychology, the operants relevant to each of these principles are shaped by their respective outcomes. Ainslie argues that the two principles can be represented as two interests, each of which seems to employ devices that undermine the other.In discussing what these devices are, [Ainslie (1992)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B1) gives a clue as to how we may speak of the operations of mental mechanisms and also how they are organised to produce phenomena in a cognitive explanation, i.e., one that conforms to the use of cognitive logic as we have defined it and to the strictures of grounded modularity as they were developed above. His first device, for instance, is precommitment, in which for instance one joins a slimming club in order to be able to call upon social pressures in order to reach long term goals. The very language of this explanation indicates the relevance of the models of cognition we have developed. The processes are unobservable, adopted in order to make behaviour intelligible once the extensional explanations of behavioural and neuro-science have been exhausted. Secondly, the interests may hide information from one another, e.g., about the imminence of rewards. Thirdly, the emotions that control short-term responding may be incapable of suppression once they are in train or they may be foreshortened by long-term interests. Finally, current decisions may be used as predictors of the whole pattern of behaviour, consisting in a sequence of multiple behaviours belonging to the same operant class, that the individual will engage in future. An individual may, that is, see her present decision of a chocolate éclair as indicative that she will make this selection repeatedly and often in the future. Individual decisions are thus perceived as precedents. The resulting strategy is what Ainslie later described as bundling, in which the outcomes of a series of future events are seen cumulatively as giving rise to a single value. When this value, rather than that of a single future event, is brought into collision with the value of the single immediate decision, the long-term interest is thereby strengthened (see also [Baumeister and Vohs, 2003](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B8)).

Subsequent behaviour that serves the longer rather than the shorter term interest is apparently rule governed rather than contingency shaped ([Skinner, 1969](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B116)). However, the ‘rules’ exist only in the mind of the individual who may not have encountered the contingencies. It is intellectually dishonest to refer to them as rules in the sense proffered by radical behaviourists which require empirical confirmation that the individual has previously encountered similar contingencies or whose rule following behaviour from others of similar kind to the present has been reinforced. Since we have no empirical, in particular, experimental indication of this nature, we would more accurately refer to them as beliefs. Our use of intentional language indicates the nature of our explanation or, better perhaps, interpretation. Ainslie himself refers to bundling as the basis of ‘personal rules’ but we can have no this- personal evidence of even the existence of such, let alone their efficacy. Better to characterize our explanation as interpretation and make this explicit by using intentional language.In sum, Ainslie’s neuroeconomic Managerial decision picoeconomics portrays the conflict between a smaller reward that is available sooner and a larger reward available later in terms of clashing intrapersonal interests. We can now proceed to evaluate neuroeconomic Managerial decision picoeconomics in terms of the criteria set out above.

Ainslie’s neuroeconomic Managerial decision picoeconomics portrays the conflict between a smaller reward that is available sooner and a larger reward available later in terms of clashing intrapersonal interests. These are personal level events because their purpose is to render intelligible the behaviour of an individual when it is no longer obvious how the contingencies of reinforcement/punishment and his neurophysiology are affecting his behaviour. The behaviour we are attempting to understand is often a single instance of activity (we are taking a molecular perspective) but the behaviour which we employ to generate and justify the intentional interpretation we have to make is a pattern of behaviour: here we are taking a molar standpoint. There must also be a pattern of neurophysiological activity which supports the strategic assumptions we are making about the individual. In addition, the pattern of reinforcement ([Foxall, 2013](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B52)) is of crucial importance in interpreting his behaviour. We are ascribinginterests and their effects in determining behaviour but we employ constructs in order to accomplish this that are unobservable posits: they cannot enter into an experimental analysis. We use the molar behaviour pattern, the pattern of reinforcement and neurophysiology to underpin these strategic assumptions and to justify our interpretation. The language of neuroeconomic Managerial decision picoeconomics consists therefore in strategic assumptions that derive from an interpretation of the behaviour and neurophysiology of the individual. The strategic assumptions we make and the way we use them must be consistent with the evolution of the species by natural selection, the ontogenetic development of the individual’s behaviour through operancy, and the evolutionary psychology of the prevalent behaviour of the species. We need to show how the behavioural sensitivity to patterns of reinforcement (which are the subject of our studies of operancy and evolutionary psychology) are in turn related to evolution by natural selection via synaptic plasticity.

Neuroeconomic Managerial decision picoeconomics explanations for behaviour using intentional language, specifically the cognitive language of decision-making and problem-solving. In particular, as a theory of ‘the strategic interaction of successive motivational states within the person’ ([Ainslie, 1992](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B1)), it is dynamically concerned with the internal weighing of information about the outcomes of alternative courses of action and the motivational states they engender. Can the actions of the interests themselves be economically modeled at the intentional level? Is Ainslie’s neuroeconomic Managerial decision picoeconomics entirely a cognitive theory or does it lend itself to microeconomic analysis? In fact, [Ross (2012)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B84) puts forward an array of economic models of the strategic interactions proposed by neuroeconomic Managerial decision picoeconomics among competing preferences. Analysis of behaviour in terms of the pattern of reinforcement it has previously resulted in draws upon operant behavioural economics which is central to the MEBDS: specifically, the analysis of discounting relates behaviour to its consequences, but operant behavioural economics also establishes that individuals maximize utility and the particular combinations of reinforcement that constitute utility.

It is particularly important from the point of view of the research program within which the current investigation is being performed (see [Foxall, 2007a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B48)) that the cognitive interpretation of behaviour, here neuroeconomic Managerial decision picoeconomics, can be defended philosophically in terms of the underlying behavioural and neuroscience ([Foxall, 2004](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B47)). This is clearly the case with neuroeconomic Managerial decision picoeconomics ([Foxall, 2007b](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B49)).Now that neuroeconomic Managerial decision picoeconomics has been established as a cognitive component for neuro-behavioural decision theory, its usefulness as a means of overcoming Managerial dysfunction with respect to temporal horizon can be evaluated. As Section Managerial Organisation-Level Strategies for Changing Managerial Behaviour indicates, the general thrust of neuroeconomic Managerial decision picoeconomics is towards clinical application that may not fit most Managerial situations. In that case, alternative approaches to management are discussed, notably adaption-innovation theory, which are founded on similar neurophysiological bases but which suggest more practicable solutions. An advantage of neuroeconomic Managerial decision picoeconomics in the current context is that it suggests means of overcoming the Managerial problems likely to arise when individual Managers are strongly motivated by the goals and behavioural patterns that reflect hyperactivity in the impulsive system and hypoactivity in the executive system. [Ainslie (1992)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B1)proposes a number of strategies through which the individual might overcome the temporal discounting that is the hallmark of this tendency. It is here that RST underpins the current analysis by providing neurophysiological systems that underlie not only the more extreme impulsive—approach tendency (BAS) the fear—engendered escape—avoidance tendency (FFFS), but the goal-resolving tendency that seeks to reconcile the alternative courses of action (BIS). The strategies of self-control suggested by Ainslie can be seen as attempts to aid the BIS in its attempts at conflict-resolution. The relevance of these strategies to Managerial decision-making of the kind we have been discussing is evident though it is unclear whether a Manager would be able to recognize and change his or her behaviour in the absence of detailed one-on-one counseling. While this methodology obviously has applications in therapeutic contexts, and Ainslie’s prescriptions fit well the needs of substance and behavioural addicts, an application that is more attuned to the social-structural demands of Managerial management is called for in the context with which we are here concerned.

There exists an alternative approach to Managerial application of the neuropsychological work that has been reviewed in this section, though the following comments are indicative and call for a dedicated research program. Adaption-innovation theory ([Kirton, 2003](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B63)) suggests a means of structuring decision-making groups that reflects competing neuro-behavioural systems and so avoids reliance on an individual-level prescription for Managerial behaviour. ‘Cognitive style’ refers to a person’s persistent preferred manner of making decisions, the characteristic way in which they approach problems, information gathering and processing, and the kinds of solution they are likely to work towards and attempt to implement. As such, it is orthogonal to cognitive level, that is intelligence or capacity. [Kirton (2003)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B63)proposes that individuals’ cognitive styles can be arrayed on a continuum from those that predispose ‘doing better’ (the adaptive pole) to those that predispose ‘doing differently’ (the innovative pole). Adaption-innovation is measured by the Kirton Adaption-Innovation Inventory (KAI) which evinces high levels of reliability and validity and scores correlate with a number of personality variables including extraversion and impulsivity. General population samples indicate that trait adaption-innovation is approximately normally distributed and general population scores, including of course those of Managers, are arrayed over a limited continuum which falls within the theoretical spectrum of scores posited by adaption-innovation theory. In line with the purview of this section, therefore, the Managers of whom we speak are not extreme in their behaviours, though they some of them may exhibit scores towards the extremes of the bipolar construct of adaption-innovation. The behaviour of the extreme adaptor is generally characterized by a tendency towards caution in decision-making and problem-solving, use of tried-and-tested methods, efficiency, rule-conformity and limited quantitative creativity manifesting in the generation of relatively few, workable solutions. The extreme innovator is, in contrast, more outlandish in selecting decisions, more likely to propose novel solutions to problems (many of which are impracticable), less efficient and more likely to modify or even break the rules. Although extraversion (measured, for example, by Eysenck’s E scale) emerges as more highly correlated with adaption-innovation (measured in the direction of the innovativeness pole), little is known about the underlying personality profiles of adaptive and innovative decision-makers in relation to the contingencies of reinforcement that shape and maintain their preferred behavioural styles. RST ([Gray and McNaughton, 2000](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B57);[McNaughton and Corr, 2004](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B72); [Corr, 2008a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B36)) offers a means of investigating the personality profiles of decision-makers and the role of reward and punishment in their development and maintenance. This all suggests that a psychometric research program concerned with the integration of a number of fields could provide indicators for the prescription to the problems of extreme Managerial style. The program would need to encompass the neurophysiology of cognition together with the psychometric measurement of personality dimensions that underlie cognitive style. Enough has been said to indicate that we understand these fields and their interactions sufficiently to embark on such a program. In the meantime, the following remarks are indicative of the work that needs to be undertaken.

In contradistinction to innovators, adapters are typically prudent, using tried and tested methods, cautious, apparently impervious to boredom and unwilling to bend, let alone break, the rules. They seek the kind of efficiency that manifests in accomplishing known tasks more effectively. An extremely adaptive cognitive style suggests hyperactivity of the executive system coupled with hypoactivity of the impulsive system. Moreover, those aspects of the executive system that involve ToM, the observation of social conventions, meta-cognition, and some facets of behavioural flexibility might be adaptor characteristics that would confirm this categorization. The tentative conclusion is that adaptors would cope well and perform advantageously when involved in the intellectual, long-term, detailed thinking that strategic planning requires. The downside to their over-involvement in this kind of decision-making derives from the demands that strategic planning and commitment sometimes exert upon the ability to undertake ‘outside-the-paradigm’ thinking. Such demands are likely to be, relatively, occasional but they are equally likely to arise at times of crisis in the market and competitive environments of firms and to benefit most from the kind of thinking which characterizes a more innovative cognitive style. In contradistinction to adaptors, innovators typically proliferate ideas that require the relatively radical change that can modify strategic direction, the product-market scope of the firm, and possibly diversification. At its extreme however, this cognitive style, suggests hypoactivity of the executive system, hyperactivity of the impulsive system. The impulsive system is geared to the rapid identification and evaluation of opportunities and threats, the capacity to envisage far-reaching, possibly disruptive, change which, in refocusing the entire strategic scope of the enterprise carries with it upheaval in working practices and both the working and non-working lives of Managers and other employees. To the extent that these are innovator-traits, it is clear that decision groups need to be balanced by adaptors who can supply the capacity for sounder decision-making and the facilitators who can explain to innovators the rationale behind the behaviour of adaptors, who are otherwise likely to be seen as too slow-moving to respond appropriately to the crisis, and to adaptors that which underpins the behaviour of innovators who would otherwise be perceived as too outlandish to preserve the values of the Managerial Organisation. Innovators supply strengths in Managerial decision-making: they are more likely to think outside the paradigm within which a problem has arisen, unconfined by the tried and tested methods currently in place, and to take risks. These are all relevant when the Managerial Organisation faces grave uncertainties and requires radical strategic reManagerial Organisation. But innovators may be unsuited to more short-term decision-making which requires the skills of prudence and caution which are the hallmark of the adapter.

Normally, strategic thinking and planning require the adventurous outlook of the innovator, tempered by the prudence of the adapter. But, without top management vigilance and the planning of the teams that participate in decision-making, it might well attract a preponderance of extreme adapters. If this cognitive style dominates the strategic function, there is likely to be a dysfunctional emphasis on the planning of strategy at the expense of the taking of strategic decisions and the implementation of appropriate policies at the operational and administrative levels. Insofar as strategic decisions are unprogrammed, they therefore require the inputs of innovators. So a prolonged predominance of adapters in this role will lead to Managerial imbalance. Normally, operational (and administrative) functions require the efficient involvement of the adapter, tempered by the more outward-looking tendency of the innovator. But, again without top management vigilance, they might attract the extreme innovator who seeks to take risks for short-term benefits. This will interfere with the strategic management of the enterprise and could jeopardize the overall operation of the firm.

‘Strategic’ decisions do not necessarily arise at a Managerial level that is automatically higher than that of any other kind of decision, nor do strategic decisions inherently involve the breaking of paradigms, and innovativeness. Just because strategy involves long-range planning does not preclude its occurring within a paradigm, albeit of grand scope, that is nevertheless known and generally-accepted; equally, the innovativeness of eroding boundaries between small-scale Managerial systems should not be automatically diminished ([Jablokow, 2005](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B60)). Adaptive and innovative styles of cognition and creativity are constantly required, alongside one another, in the solving of problems. That which predominates appropriately in any given situation depends entirely on the specific context. Managerial problems arise when current strategies no longer fit the demands of the Managerial environment: when markets, reflecting demand and competition, are no longer adequately served by the norms of Managerial behaviour ([Jablokow and Kirton, 2009](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B61)). Such changing circumstances have two vital components. The first is the changing environment must be perceived as involving precipitating events, i.e., the need for change by the Managerial Organisation’s leaders; it is adaptors rather than innovators who are more adept at detecting unforeseen developments that require Managerial action. The second is the exploitation of the opportunities such external change is prompting, or the defensive action needed to avoid the threats that the environment contains; these tasks of advancing the required action are more likely taken effectively by the more innovative ([Tubbs et al., 2012](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B101)). This is a matter of cognitive style, not of cognitive or decision level.This point is summarized by the ‘paradox of structure’ ([Kirton, 2003](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B63), pp. 126–134): while Managers require structure whatever their cognitive style, but that structure is ultimately stultifying as persons, Managerial Organisations and environments exhibit dynamic behaviours. All the more reason for founding Managerial teams and behaviour patterns on the contributions of all cognitive styles.

[van der Molen (1994)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B102) notes on the basis of evolutionary logic that social animals are motivated by two counterposed tendencies: first, to find satisfaction in the company of conspecifics which requires a degree of cooperation and conformity; secondly, to compete with conspecifics for limited resources, such as food, sexual partners, and territory, on which individual survival and biological fitness rely. The personality characteristics which reflect these motivational forces are, in turn, ‘strongly intercorrelated’ traits such as ‘self-will, thing-orientation, individualism and innovative creativity on the one pole and compliance, person-orientation, sociability, conformity and creative adaptiveness on the other. Individuals differ from one another as far as the balance between these polarities [is] concerned. This variation between individuals must have genetic components’ ([van der Molen, 1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B102), p. 140).Drawing on the work of [Cloninger (1986](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B33), [1987](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B34)), [van der Molen (1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B102), pp. 150–152; see also [Skinner and Fox-Francoeur, 2013](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B95)) makes a strong case for the evolutionary and genetic components of adaption—innovation. Cloninger’s ‘novelty-seeking’ and ‘reward dependence’ dimensions of personality are especially pertinent. The former is driven predominantly by the neurotransmitter DA which manifests in behaviour that seeks to alleviate boredom and monotony, to deliver the sense of exhilaration and excitement that is generally termed ‘sensation-seeking’ ([Zuckerman, 1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B110)); these individuals demonstrate a tendency to be ‘impulsive, quick-tempered and disorderly… quickly distracted or bored… easily provoked to prepare for flight or fight’ ([van der Molen, 1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B102), p. 151). ‘Reward dependent’ individuals are, in contrast, highly dependent on ‘social reward and approval, sentiment and succour’; they are ‘eager to help and please others, persistent, industrious, warmly sympathetic, sentimental, and sensitive to social cues, praise and personal succour, but also able to delay gratification with the expectation of eventually being socially rewarded’ (ibid). These individuals’ behaviour is strongly controlled by the monoamine neuromodulator norepinephrine.

Which of these bundles of attributes manifests in behaviour that marks out some individuals as leaders depends entirely on the demands of the Managerial situation: retail banking, relying for the most part on the implementation of standard operating procedures, may have a natural tendency to encourage and reward those behaviours that reflect an adaptive cognitive style; pharmaceutical companies, whose technological, demand and competitive environments reflect a greater dynamism than is ordinarily the norm for retail banking, requires for a much larger part of its activities the presence of individuals whose cognitive and creative styles are predominantly innovative. Investment banking which is expected to reflect a large adaptively-creative style of operation but which attracts innovators is in danger of becoming the kind of ‘casino banking’ that has been so deleterious to both corporate and general social welfare in the last decade. But the inability of an Managerial Organisation to achieve the right cognitive and creative accommodation to its environment will predictably culminate in catastrophe. For the retail bank whose leaders fail to perceive and respond appropriately to the changing international competition in high-street banking, the pharmaceutical firm that becomes over-involved in the development and marketing of drugs that are novel in the extreme, and for the investment bank that over-emphasizes innovative creativity to the point where reckless decisions are made, catastrophe is equally probable. Predominant Managerial climate, adaptive or innovative, can be disastrous if either of these cognitive styles comes to predominate. These behavioural styles are remarkably consonant the innovative and adaptive cognitive/creative styles, respectively, described by [Kirton (2003)](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B63). Their prevalence and likely genetic basis is borne out by their consistency with the RST described above ([Corr, 2008a](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B36); see also [Eysenck, 2006](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B45)), though the terminology may vary. The incorporation of adaption-innovation theory into the framework of conceptualization and analysis also suggests a wider search for the neurophysiological basis of styles of creativity. But these are matters for further research.

Analyses of Managerial behaviour in neurophysiological terms raise two difficulties. The first is conceptual: such explanations conflate cognitive processes with neurophysiological events; the second relates to practical management: such explanations offer little by way of solution to the personal and Managerial problems that result from behaviour that is motivated by excess influence of either Managers’ impulsive systems or their executive systems. This section has sought to contribute to the resolution of the conceptual problem, by introducing a cognitive dimension, neuroeconomic Managerial decision picoeconomics, into neuro-behavioural decision theory, and the adaption—innovation theory of cognitive styles to that of the practical problem by deriving prescriptions for changing Managerial behaviour. The prime conclusion is that the use of neurophysiological theory and research in the conceptualization of Managerial decision-making and in approaching the solution of problems that arise therein is entirely justified but needs to be qualified by practical considerations suggested by the nature of Managerial work and the ways in which Managerial behaviour can be modified especially in the context of large-scale Managerial Organisations. Prior to such activity, however, is the resolution of conceptual problems in the explanation of individual behaviour on the basis of neurophysiological events. This section has pursued a central requirement of neuro-behavioural decision theory’s use of intentional terminology to explain human behaviour: the role of cognitive terminology and its implication for the shape of the overall theory. It has argued that neuroeconomic Managerial decision picoeconomics provides a valuable means of inculcating a cognitive level of explanation into the theory and that one of its advantages is that it suggests solutions to hyperactivity in one or other of the impulsive and executive systems identified by the theory which is exacerbated by hypoactivity in the alternative system. The solutions proposed by neuroeconomic Managerial decision picoeconomics may, however, be most suitable for remedial action in clinical settings rather than in Managerial settings. The quest for solutions to Managerial problems is more readily achieved through Managerial Organisation-level models of Managerial activity that incorporate as fully as possible neurophysiological understandings of behaviour that are compatible with those found in neuro-behavioural decision theory. One possibility in the present context is the application of adaption-innovation theory, dimensions of which are known to map reliably on to the neurophysiological and cognitive/personality factors that underpin impulsive and executive systems. The proposal that Managerial teams be built and managed in ways that reflect these considerations suggests the most relevant applications of neuro- and behavioural science, with cognitive psychology, for the remediation of certain Managerial excesses. These conclusions lead predictably to a call for further research along the lines indicated. The advantage of this emphasis on cognitive style is that it differentiates Managers on the basis of their susceptibility to hyper- or hypo-activity of either the impulsive or executive systems; and recognizing that the Managerial functions with which we are concerned are populated by Managers of widely differing cognitive styles should reduce our tendencies to stereotype Managers on the basis of their broadly-defined functional roles ([Foxall and Hackett, 1994](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B53); [Foxall and Minkes, 1996](http://journal.frontiersin.org/Journal/10.3389/fnhum.2014.00184/full#B54)). The neurophysiological foundations of adaption-innovation as presented here do not map directly on to those of RST or neuro-behavioural decision theory. But there is sufficient overlap to motivate further investigation.

To the degree that neuroeconomists have sought to provide neural foundations for revisionist behavioural economics, the results have in general been unconvincing. However, the chronologically original brand of neuroeconomics, which developed organically from the study of reward processing and learning by computational learning theorists, consistently demonstrates applications of sound economic methods. Furthermore, its most explicit methodological architect, Paul Glimcher, has clearly articulated a research program that directly and formally integrates computational learning theory with standard microeconomics. Neuroeconomics has further bridged the once disparate fields of economics and psychology, largely due to movement within economics. Change has occurred within economics because the most important findings in neuroeconomics have posed a challenge to the standard economic perspective. Neuroeconomics has primarily challenged the standard economic assumption that decision making is a unitary process—a simple matter of integrated and coherent utility maximization—suggesting instead that it is driven by the interaction between automatic and controlled processes. Neuroeconomic research has focused most intensely on decision making under risk and uncertainty, but this line of research provides only mixed support for a dual systems perspective. The degree to which intertemporal decision is generated by multiple systems with conflicting priorities is perhaps the most hotly debated issue within neuroeconomics. However, a majority of the evidence favours a multiple systems perspective. Neuroeconomic research on preferences is highly supportive of a dual systems explanation, although the most prominent studies come to conflicting conclusions regarding how self-interest and fairness concerns interact to influence behaviour. Neuroeconomics may ultimately influence psychology indirectly, via its influence on economics (by inspiring economic models increasingly grounded in psychological reality), and directly, by addressing debates of interest within psychology (whether multiple systems operate sequentially or in parallel to influence behaviour).

For the Managerial decision economist, neurodecision Economics is to extend scope of decision-making models and enrich contents. Unfortunately, at variance with the neuroscientists most often enthusiastic toward this scientific challenge, a majority of decision Economics remains much more skeptical about its positive outcome for decision Economics. They rightly pointed out several weaknesses. The precise nature of relation between the information given by the neuro - images and the features of the individual mental states revealed by the experimental material is still uncertain and it’s meaning relatively ambiguous. Furthermore, in the best case when this relation is clean, Managerial decision economists often wonder how they can use the results of those studies for performing the analysis of the decision-making processes in the real economic life. This Chapter includes an exposition of how exponential accumulation of knowledge in neuromanagement decision can potentially enrich research on management decision making, assortment of techniques in neuromanagement decision that can be used to shed light on various management decision making phenomena, examples of potential research in this emerging area, and some challenges while venturing into this new area of research. Purpose is primarily to clarify those points in opening a debate on economic relevance of neuroeconomic program. Dissimilar illustrations of their fruitful contributions are offered. Initial part of the issue is devoted to methodological arguments in favour of such a program which improves economic knowledge. Second part focuses on specific applications in Managerial decision making. Finally, critical evaluation of information offered by dissimilar tools of brain investigation is proposed.

Neuroeconomic theory will soon play a crucial role in the building of new reliable theories capable of explaining and predicting individual behaviour and strategic decisions. Principal message is that individual is not one coherent body. Brain is a multi-system entity (with conflicting objectives, restricted information, etc.) and consequently decision-maker must be modelled as an organisation. We conclude with an analogy. Before the so-called contemporary theory of the firm, organisations were modelled as individual players characterised by an input-output production function. Methodical study of interactions between agents and decision processes within organisations (acknowledging informational asymmetries, incentive problems, restricted communications channels, hierarchical structures, etc.) led to novel economic insights. Applying a similar methodology to study individual decision-making is, in our view, the most fruitful way to understand the bounds of rationality.

Can its findings contribute to a renewal of contemporary economics in a neo-humanistic, more empathetic, and at the same time more realistic approach? Can this orientation offer a practical path toward realizing the ideals so eloquently stated? Could there be a better description of, and direction for, what neuroeconomics might achieve in the years ahead? We must ask whether, and how, neuroeconomics could develop a more down-to-earth approach to human decision-making that maintains fundamental connections to the questions that classical anthropology poses to humanity ; Why, where from, where to, who and now, ‘how’?

**Construct of Cognitive Style:** The key aims of this article are to relate the construct of cognitive style to current theories in cognitive psychology and neuroscience and to outline a framework that integrates the findings on individual differences in cognition across different disciplines. First, we characterize cognitive style as patterns of adaptation to the external world that develop on the basis of innate predispositions, the interactions among which are shaped by changing environmental demands. Second, we show that research on cognitive style in psychology, in cross-cultural neuroscience, on learning styles in education, and on decision-making styles in business and management all address the same phenomena. Third, we review cognitive psychology and neuroscience research that supports the validity of the concept of cognitive style. Fourth, we show that various styles from disparate disciplines can be organised into a single taxonomy. This taxonomy allows us to integrate all the well-documented cognitive, learning, and decision-making styles; all of these style types correspond to adaptive systems that draw on different levels of information processing. Finally, we discuss how the proposed approach might promote greater coherence in research and application in education, in business and management, and in other disciplines. Historically, the term ‘cognitive style’ refers to consistencies in an individual’s manner of cognitive functioning, particularly in acquiring and processing information (Ausburn&Ausburn, 1978). Messick (1976) defines cognitive styles as stable attitudes, preferences, or habitual strategies that determine individuals’ modes of perception, memory, thought, and problem solving. Similarly, Witkin, Moore, Goodenough, and Cox (1977) characterize cognitive styles as individual differences in the ways Managers perceive, think, solve problems, learn, and relate to others. Although it seems obvious that there are differences in how Managers habitually process information, it is not obvious how best to characterize such differences or determine their significance. Despite being very popular throughout the 1950s–1970s, research on cognitive styles has been seriously questioned in recent decades. Currently, many cognitive scientists appear to believe that research on this topic has reached a standstill and doubt whether the concept of cognitive style has utility. In fact, many researchers in basic and applied fields of psychology now use concepts such as ‘perceptual affordances,’ ‘dispositions,’ ‘patterns of learning,’and ‘learning orientations’ to conceptualize differences in how individuals perceive and interpret information, and to avoid the negative connotations associated with the idea of ‘cognitive style’.

Despite the rapid decline in research on cognitive styles in mainstream psychology by the end of the 1970s, in applied fields (e.g., education, business and management) publications on the topic continued to increase dramatically—reflecting the high practical value of the construct in applied settings. However, working in isolation from one another, researchers in each of the applied fields developed their own terminologies, such as ‘learning style’ (education) or ‘neuroManagerial economic decision-making style’ (business and management). And these terms did not have clear definitions nor was it clear how they differed from traditional characterizations of cognitive styles. Furthermore, some applied practitioners made frequent reference to, and focused on, naïve or outdated assumptions about how the brain processes information (e.g., the popular narrative about left brain versus right brain differences) or confounded and combined cognitive style with other psychological constructs. These efforts produced more chaos and led to greater skepticism among cognitive psychologists and neuroscientists about the utility of the concept of cognitive style.

As many reviews have noted (Curry, 1990; Evans & Cools, 2011; Kogan&Saarni, 1990; Kozhevnikov, 2007; Rayner & Cools, 2011; Sternberg &Grigorenko, 1997; Zhang, Sternberg, & Rayner, 2012), one reason that the concept of cognitive style fell short is the lack of a framework that unites and systematizes hundreds of proposed style dimensions. In response, advocates of the construct of cognitive style have proposed a variety of unifying frameworks (e.g., Allinson& Hayes, 1996; Curry, 1983; Riding and Cheema, 1991; Sternberg &Grigorenko, 1997). Although some of these frameworks are sophisticated and elegant, as we will show in the present paper, they did not solve the problem. In particular, none of these frameworks integrated the cognitive style construct with contemporary cognitive psychology and neuroscience theories of information processing; in fact, because the vast majority of cognitive style studies were conducted before the rise of cognitive science, the concept of cognitive style has not been integrated with contemporary theories of cognition. Moreover, mainstream cognitive psychology and neuroscience have been primarily focused on the capacities and constraints all human minds have in common, and until recently barely considered individual differences in cognition. Thus, the basic-science fields could not offer the applied fields a coherent framework to organise and understand individual differences in cognition to which the concept of cognitive style could have been mapped. Thus, although cognitive style refers to ways of processing information, a relationship between the construct of cognitive style and contemporary information processing theories has never been firmly established.

Systematic cognitive psychology and neuroscience research on individual differences in cognition gained traction in 1990s (e.g., Kosslyn et al., 1996), but most of this work focused on such basic factors as speed of processing, working memory capacity, and general fluid intelligence. Although variations in all of these factors could lead an individual to cope with specific environmental challenges more or less effectively, the research on individual differences did not have this focus; rather, the research focused on variations in functioning of specific aspects of information per se. In contrast, cognitive style researchers consistently used the concept of cognitive style to describe individual differences in cognition that help the individual to adapt to physical and socio-cultural events and circumstances. As such, a particular cognitive style represents particular environmentally sensitive individual differences in cognition that arise from a system of interacting processes, not a single process working in isolation: the system takes individual differences in basic processes (e.g., speed of processing ,working memory) as constraints while environmental influences and the socio-cultural environment engender particular habitual approaches to processing. The sorts of individual differences in cognition that underlie cognitive styles are likely to change only when the physical or socio-cultural environment itself changes in fundamental ways (Klein, 1951; Witkin, Dyk, Faterson, Goodenough, & Karp, 1962). The idea that cognitive style is an adaptive system that is constrained by basic processes invites a novel approach to understanding cognitive styles.

The concept of cognitive style was introduced by Klein (called ‘perceptual attitudes’) in the early 50s to describe cognitive processing that helps an individual to cope with the requirements of his/her environment. To examine how accurately individuals make judgments about changes in perceptual stimuli, Klein (1951) showed participants projected squares that constantly changed in size, and distinguished two types of individuals: ‘sharpeners’ who tended to notice contrasts and had the ability to maintain a high degree of stimulus differentiation, and ‘levelers’ who were most likely to notice similarities among stimuli and ignore the differences. Klein (1951) proposed that cognitive style can be conceptualized as ‘patterns of adaptation to the external environment’ that regulate an individual’s cognitive functioning. In support of his theory, Klein reported that in terms of personality, the leveler group exhibited a ‘self-inwardness’ pattern characterized by ‘a retreat from objects, avoidance of competition or any situation requiring active manipulation’ (Klein, 1951, p. 339). Sharpeners, on the other hand, were more manipulative and active, and had high needs for attainment and autonomy. Thus, Klein considered both poles of the leveling/sharpening dimension as equally useful in helping an individual adapt to, and function in, the environment (i.e., each pole presents a way for individuals to achieve a satisfactory equilibrium between their inner needs and outer requirements) -- but the styles drew on different information processing capacities. Several years later, Holzman and Klein (1954, p. 105) defined cognitive styles as ‘generic regulatory principles’ or ‘preferred forms of cognitive regulation’ in the sense that they are an ‘organism's typical means of resolving adaptive requirements posed by certain types of cognitive problems’.

At about the same time, Witkin et al. (1954) carried out their first large-scale experimental study of field dependence/independence, which led them to distinguish between field-dependent (FD) individuals, who depend on the surrounding context, and field-independent (FI) individuals, who did not depend on the surrounding context. Researchers also reported a relationship between participants' performance on perceptual tests, their personality characteristics, and social behaviour. FD Managers were more attentive to social cues than were FI Managers, and FI Managers had a more impersonal orientation, psychologically and physically distancing themselves from other Managers (see also Witkin&Goodenough, 1981 for a review). Witkin et al. concluded that although the ‘core’ of cognitive style might be rooted in an individual’s innate predispositions, the two opposite poles of the field-dependency-independency style dimension represent outcomes of different modes of adjustment to the world.

Thus, similar to Klein, Witkin et al. (1954) considered cognitive style to be ‘patterns or modes of adjustment to the world’; in their view, everyone adapts as best as possible, given his or her basic capacities, to the requirements of the external environment. Later, Witkin and Berry (1975) comprehensively reviewed cross-cultural studies of FD-FI individuals, and suggested that cognitive style can be conceptualized as environmentally and culturally sensitive individual difference in cognition -- and could be predicted from the analysis of an individual’s cultural and acculturation characteristics (based on an ‘ecological analysis’; Berry, 1980).

Witkin and his colleagues, however, did not fully elaborate their theory, and as a consequence, conceptualizing cognitive style as environmentally sensitive individual differences in cognition was somehow overlooked during later research in the1950s, when a tremendous number of ‘styles’ appeared in the literature; such styles included impulsivity/reflectivity (Kagan, 1966), tolerance for instability (Klein & Schlesinger, 1951), breadth of categorization (Pettigrew, 1958), field articulation (Messick&Fritzky, 1963), conceptual articulation (Messick, 1976), conceptual complexity (Harvey, Hunt, & Schroder, 1961), range of scanning, constricted/flexible controls (Gardner, Holzman, Klein, Linton, & Spence, 1959), holist/serialist (Pask, 1972), verbalizer/visualizer (Paivio, 1971), locus of control (Rotter, 1966), and many others.

Studies of these styles typically focused on lower-order cognitive tasks, often assessed by performance measures (error rate and response time) with simple ‘right’ and ‘wrong’ answers. This approach is especially evident in the most common measures of cognitive styles, such as Witkin et al.’s (1954) Embedded Figures Test (EFT) and Kagan’s Matching Familiar Figures Test (MFFT; Kagan, Rosman, Day, Albert, & Phillips, 1964). Instead of measuring bipolar dimensions that represent two equally efficient ways of solving tasks, in reality these tests measure only a single pole of the dimension (e.g., the EFT assesses only the level of field-independency). The result is that these tests are more like tests of spatial ability than measures of a style. Given the nature of the tests, it is not surprising that researchers often found a correlation between intelligence and cognitive style tests (e.g., Cooperman, 1980;Goodenough& Karp, 1961; McKenna, 1984), sparking ongoing debates as to whether two opposite poles of cognitive style dimensions have an equal value or whether some of them, such as field-independence, sharpening, narrow categorization, and others, are simply indicators of greater intelligence.

Furthermore, because the majority of these studies were conducted before the advent of cognitive science, they lacked a unifying theoretical approach to information processing, which could lay the foundation for systematizing numerous overlapping cognitive style dimensions. In the 1970s, mainstream cognitive psychology and neuroscience were primarily focused on the capacities and constraints all human minds have in common, and until recently barely considered individual differences in cognition. Thus, cognitive science did not provide a coherent framework of individual differences in cognition that could have been used to organise and understand the various proposed cognitive styles. Consequently, the potential benefits of studying cognitive styles were lost amidst the chaos, and research on cognitive style declined dramatically by the end of the 1970s.

The first category includes studies that support the existence of cognitive styles (‘meta-styles’) that operate on a metacognitive level (e.g., Keller & Ripoll, 2001; Kholodnaya, 2002; Niaz, 1987). The existence of such metastyles (e.g., mobility/fixity) had already been suggested by Witkin -- who was the first to point out that there might be ‘mobile’ individuals who possess both FD and FI characteristics and can employ one style or the other depending on the situation (Witkin, 1965; Witkin et al., 1962) -- as well as by other early researchers (e.g., Eska& Black, 1971; Pinston, 1978). A decade later, Niaz (1987) identified four groups of college students on the basis of their field-dependence/independence and intelligence measures: mobile FI, mobile FD, fixed FI, and fixed FD. Niaz showed that the fixed FI group received the highest intelligence scores among all the groups, but mobile individuals (both FD and FI) performed significantly better than all other groups in three college courses (chemistry, mathematics, and biology). More recently, Kholodnaya (2002) administered a number of different conventional cognitive style measures (i.e., of field dependence/ independence, constricted/flexible cognitive control, impulsivity/reflexivity, and narrow/wide range of equivalence) and intelligence tests. Using cluster analysis, Kholodnaya demonstrated that each of the cognitive style dimensions could be split further along mobile versus fixed subcategories. Reviewing the literature on the mobility of styles, Kozhevnikov (2007) suggested that mobility/fixity can be viewed as a ‘metastyle’ that defines the level of flexibility with which an individual can choose a particular cognitive style in a particular situation.

A second trend in recent cognitive style studies has focused on reformulating the concept of cognitive style within a unifying theoretical framework. One of the examples of these attempts is Sternberg’s theory of thinking styles (Sternberg, 1988; Sternberg, 1997; Sternberg &Grigorenko, 1997), which differs from previous theories because it does not systematize existing cognitive styles but offers a new multidimensional system of intellectual (originally, ‘thinking’) styles. The model uses the structure of real government as a metaphor for understanding and explaining individual differences in the regulation of a person’s intellectual activity. Although Sternberg's (1988) original theory described 13 thinking styles, numerous follow-up studies (Zhang & Sternberg, 2000) revealed that most of these styles can be classified into two main groups: Type I styles that are more creativity-generating and denote higher levels of cognitive complexity (e.g., legislative, judicial, hierarchical, global, and liberal styles) and Type II styles that suggest a norm-favouring tendency and denote lower levels of cognitive complexity (e.g., executive, local, monarchic, and conservative), with the remaining styles including characteristics from both groups, depending on the demands of the specific task. However, even this innovative approach did not solve the problem of integrating the cognitive style construct into contemporary theories of cognitive psychology and neuroscience nor did it explain the possible relationship between the posited thinking styles and existing cognitive style dimensions.

A third category of recent cognitive style research includes theoretical studies that attempted to build hierarchical models of cognitive styles on the basis of information processing theories (e.g., Miller, 1987, 1991). Although criticized for the lack of empirical support (Zhang & Sternberg, 2005), Miller (1987) proposed a hierarchical ‘model of individual differences in cognitive processing’ in which he posited two dimensions: A horizontal dimension specified an analytic/holistic style continuum and a vertical dimension specified different stages of cognitive processing, such as perception (pattern recognition and attention), memory (representation, organisation, and retrieval), and thought. According to Miller, at each stage of cognitive processing, one can identify different cognitive styles (Figure 1). Nosal (1990) subsequently introduced a similar model of cognitive style with four main stages of information processing: perception, concept formation, modeling (reasoning, judgment, and neuroManagerial economic decision-making processes), and program (i.e., metacognitive). Similar to Miller’s model, Nosal suggested that different cognitive styles might be identified at each stage of information processing, for instance: field-dependence/independence represents a style operating at the perceptual level, whereas mobility/fixity is a style operating at the program (metacognitive) level. A significant innovation of Nosal’s approach is that he presented styles in a matrix form (see Figure 2), expanding the analytical-holistic continuum proposed by Miller to accommodate other cognitive style continua (families) such as 1) field structuring (context dependent vs. context independent), which describes a tendency to perceive events as separate versus inseparable from their context; 2) field scanning (rule-driven vs. intuitive), which describes a tendency for directed, driven by rules vs. intuitive information scanning; 3) equivalence range (compartmentalization vs. integration), which represents a tendency to process information as global units (simultaneous) or part-by-part (sequential), and 4) control allocation (internal vs. external locus of processing), which describes methods of locating criteria for processing at the internal vs. external center).

Nosal described these four style families as four regulatory mechanisms or ‘invariant aspects’ of information processing.

In short, the research on cognitive style in psychology suggests that some styles might operate at a superordinate metacognitive level, and such metastyles will determine the flexibility with which an individual chooses the most appropriate subordinate style for a particular situation. More generally, the research suggests that it is useful to organise styles hierarchically. Such an organisation consists of dimensions that relate to lower order cognitive processing, to higher order complex cognitive skills, and to metacognitive functioning. Moreover, cognitive style can be represented in a matrix form, with its vertical dimension representing different levels of information processing and horizontal dimension representing different cognitive style families.

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1. [↑](#footnote-ref-1)
2. [↑](#footnote-ref-2)