CHAPTER 4

THEORETICAL FOUNDATIONS OF TEMPERAMENT

In the end you are – what you are.
Set on your head a wig with a million curls,
Set your feet on heels half a yard high,
Still, always, you stay what you are. *Von Goethe (2001, p. 95)*

From the previous chapter reviews a deduction that gross neurological impairment accompanies Alzheimer's disease, that all patients display erosion of cognitive functions, and most have to endure neurobehavioural and/or neuropsychiatric disturbances, seems accurate. The researchers are in fundamental agreement that neurological and neuropsychological deterioration characterise Alzheimer's disease. However, the contentious issue revolves around the diverse explanations for the individual variances in the symptomatic profile of the disease.

The dominant explanation of a one-to-one correspondence between neuropsychological impairment and specific neuropsychological impairment has proven to be an inadequate retort, based on linear causality. Several investigators have suggested that the symptomatic manifestation of dementia may be the result of a complex interaction of factors such as premorbid personality or temperament, biography, health, pathoplastic effect of personality, social-environmental influences, and distinct neurological impairment (Agnew & Morris, 1998; Berrios, 1989; Cummings, 1992; Frisoni et al., 1998; Kitwood, 1993).

Grigsby and Stevens (2000) believe that the mental or psychological, however, should not be divorced completely from their neural substrates because mental states and psychological activity are identical to and emergent from the specific processes of the brain, which function in a complex environment. Therefore, an aetiological model that allows premorbid temperament to be part of a nexus of other causal factors and not just a static trait description remains true to the psychological-neural synthesis.

The aim of this study is inter alia to elucidate the role of premorbid temperament, as part of the aetiological nexus, in the genesis of behavioural and psychiatric disturbances. This chapter attempts to clarify the methodological and theoretical aspects of temperament and its aetiological relevance for the emerging neuropsychological profiles in Alzheimer's disease. The discussion is modelled on the contentious elements that characterise temperament research namely: conceptual attributes, composition, and biological premises.

4.1 Analogues of temperament

The referents one uses to define human individuality oscillate between descriptions of temperament, personality, and character. In antiquity, thinkers such as Hippocrates believed that the disposition of a person was dependent on the four humors or fluids within the body and the Greek names for this fluid characterised the four specific temperaments (Simonov & Ershov, 1984/1991). Since those times, temperament shared with other psychological constructs a protean form and character. This descriptive inconsistency still contributes to the methodological issues in temperament research.

Scientific revisions arose to quell the controversial debates, and limit the varied definitions proposed by experts such as Eysenck, Gray, Mehrabian, Thomas, Chess, Strelau, etc. As many researchers have pointed out, attributes of personality, emotion, cognition, and behaviour contaminate the term temperament. The cumulative effect was a proliferation of descriptive traits and diagnostic tools to measure them (Strelau, 1983). For example, temperament can be understood as pertaining to any combination of more than 80 dimensions or traits identified by various authors, and traits such as negative affect can be measured as an emotional, cognitive, behavioural, or personality related function on as many as 30 psychometric instruments (Netter, 1991; Strelau, 1991; Strelau, 1994). Moreover, temperament has been attributed either a continuous or a discrete connotation, with Eysenck and Eysenck (1985), for example, considering all traits outside intelligence to be (dichotomous) temperament traits and others considering traits as degrees of temperament. The following sections outline the various meanings that have been given to the term temperament and the concomitant influence on how individual differences are perceived.

4.1.1 Temperament and personality: Interchangeable concepts

Many of the biologically oriented theorists use the term temperament and personality as interchangeable concepts. The theoretical divergence lies in the definitions that they attach to dimensions of personality. Eysenck (1966) and Gray (1991) are two theorists that equate personality and temperament but attribute different features to their models of personality. Zuckerman, Ballenger, and Post (1984) on the other hand, contend that personality traits are moulded by biological activity but had not invoked the use of the term temperament in their studies.

Eysenck (1991) proposes that personality and temperament refer to the same dimensions. His proposal has been based on the link between three factors (psychoticism, extraversion, and neuroticism) and neurobiological activity. Exogenous influences are considered as secondary determinants of personality or temperament disposition. The interaction between genetic predisposition and social interaction appears as a function of psychophysiological features such as neural structure and biochemical function.

According to Gray (1991) the lack of differentiation between the terms personality and temperament is based on the assumptions that temperament is accountable for the individual dispositional variance towards particular emotions and that situations reinforce emotional brain states. Gray (1991) contends that after factoring in cognitive aspects and intelligence the remaining variance forms the core of temperament or personality, whereas Eysenck (1991) discounts concepts such as values, attitudes, and interests from his model. Their interchangeable use of the terms therefore, rests on their restrictive formulations of core personality. Personality traits identified by Gray include anxiety, impulsivity, aggressive-defensive behaviour, and emotionality. Similar to Eysenck's (1970) model these core traits are associated with activity in brain regions comprising the behavioural inhibition, flight-fight, and behavioural approach systems.

Zuckerman (1991) favours the term personality although his explanations of traits such as impulsivity, novelty, and sensation seeking are augmented by biochemical theories. The neurochemicals associated with particular dispositions include dopamine and impulsivity, GABA and serotonin and anxiety. The chemical link with personality stems from the understanding that personality traits arise from elementary reflexes, and are governed by various behavioural activities regulated by biological mechanisms. The neuronal composition and its biochemical activity appear to be genetically determined.

Compressing the terms personality and temperament into one description, Watson (2000) considers temperament or personality to be an expansive general disposition that includes many emotional traits. For example, traits such as anxiety, depression, and hostility are considered substrates of the broader temperament dimension of neuroticism.

4.1.2 Temperament: An affective trait/state

Allport (cited in Eysenck, 1966, p. 24) proposes one of the earliest definitions of temperament as an emotional trait and suggested that

> temperament refers to the characteristic phenomenon of an individual's emotional nature, including his susceptibility to environmental stimuli, his customary strength, and speed of response, the quality of his prevailing mood, and all peculiarities of fluctuation and intensity in mood.

A derivative of this is Gray's (1991) idea that personality traits reflect the emotional underpinnings of behaviour. Mehrabian (1991) elaborates on this with the proposal that emotion states serve as a mediator between environment, disposition, and behaviour. Temperament can be defined as either an emotional trait or state, with the latter referring to a transitory condition and the former to a static condition. The emotion state or trait delineates a person's emotional responsiveness and provides a balance between variability of behaviours across events and relative stability of responses. Personality comprises the three basic temperament factors or emotion states of pleasure, arousal, and dominance.

Eysenck's (1966) view of temperament as an affective trait is inherent in his notion that personality arises from the interaction of four components namely the cognitive (intelligence), conative (character), somatic (constitution), and temperament (affective) components. The idea of temperament as an emotive component has been more recently challenged by theories espousing the behavioural connotation of temperament.

4.1.3 Temperament: A behavioural characteristic

A conceptual model of the behavioural bases of temperament, derived from developmental theories, attempts to explain the biological mechanisms of difference from the perspective of *how* an individual behaves. Researchers adopting this stance tend to focus on the reciprocal interaction between individuals and their context (Talwar, Nitz, Lerner, & Lerner, 1991). An example of this is the research by Chess and Thomas (1991) on the goodness of fit model. They state that psychological evolution is not a function of temperament itself, but rather driven by the interaction between temperament, other abilities, and environmental features. The *how* or content free notion of behaviour is encapsulated in theories of temperament that elucidate characteristics such as reactivity, activity, strength of nervous system, and mobility.

If temperament is considered as a formal characteristic of behaviour then three corollaries apply (Strelau & Zawadzki, 1993):

- Individual differences are stable and these manifest as variances in intensities (energetic traits) and time (temporal traits).
- If behaviour is comprised of temporal and energetic characteristics then temperament can be expressed in all kinds of reactions and behaviours.
- Temperament is characterised as a product of biological evolution. Therefore, individual differences are co-determined by genotypic and biophysiological mechanisms.

The energetic and temporal characteristics are interrelated, serve different functions, are driven by different microlevel and macrolevel processes and components, and represent the primary traits on the level of specificity and not on the level of superfactors as postulated by the Five-factor model (Strelau & Zawadzki, 1995). Based on the last contention, Strelau (1987b) also opposes the synonymous use of the terms temperament and personality on the assumption that its equivalence with personality cannot be reconciled with the idea of formal characteristics and the Regulative Theory of Temperament, which is a biologically oriented approach. Table 4-1 highlights a summary of the differences proposed by Strelau (1987b), which supports his view of temperament as independent of the structure of personality, and characterised by its own specificity.

Table 4-1 Differences between temperament and personality (Strelau, 1987b)

Temperament	**Personality**
Biologically based	Product of exogenous influences
Identified from infancy	Emerges at later stages of development
Individual differences observed in animals as well	Prerogative of humans
Addresses the how and why aspects (formal characteristics)	Addresses the what or content aspect of behaviour
Is a causal concept	Is a teleological concept and is an integrative function of behaviour

4.1.4 Temperament: A subclass of personality

Temperament is also described as a “subclass of personality traits, defined by appearance during the first year of life, persistence later in life, and the contribution of heredity” (Buss, 1991, p. 43). The temperament traits referred to as a subclass of personality include emotionality, activity, and sociability. In agreement, Hofstee (1991) states that temperament is a central subclass rather than a peripheral subclass of personality. In other words, he argues that it is the core of personality.

Simonov and Ershov (1984/1991) argue that temperament does not provide insight into the social characteristics of a person. This aspect, they believe, is conveyed by an individual’s personality, which incorporates the traits of temperament. They afford the term personality the highest position in a hierarchy of terms relating to individual difference. Many metaphors have been applied to explore the relationship between personality and temperament. One such metaphor equates temperament with a hard ice ball and personality with the softer snowball. The latter consolidates around the former implying that temperament is the developmental core around which personality develops (Graziano, Jensen-Campbell, & Sullivan-Logan, 1998).

Finch and Graziano (2001), who suggest that temperament mediates the relationship between personality and mental disturbances, endorse the idea of temperament as a biological foundation of personality. They proposed that this mediation may occur because of genetic influences on maturation hence, as a diasthesis element temperament regulates individual sensitivities to external stressors and socialisation.

Related to this idea of a temperament core, is Cloninger's (1987) hypothesis that the temperament traits of novelty seeking, harm avoidance, and reward dependence are associated with independent neurobiological and psychological correlates of behaviour. His temperament model, through this association, rests on the assumption that the identified traits form the genotypic component from which phenotypic components of the Big-Five (neuroticism, extraversion, conscientiousness, agreeableness, and openness) are constructed.

4.1.5 Summary

In spite of the divergent terms and descriptions proposed by several authors, most agree that temperament is relatively consistent and stable, is partially influenced by genotypic mechanisms and that dispositions of temperament are present at birth. Watson (2000) found in favour of this contention when he tested traits across a long-term interval of 7.5 years. Although subjects experienced major life transitions, and measures of disposition were taken across dissimilar situations, he showed that traits such as negative and positive affect displayed satisfactory stability longitudinally. This result augurs well for the proponents of biological based theories of temperament.

4.2 Composition of temperament

The structure of personality has evolved at the mercy of the engineers who attempted to build it. From the taxonomies of the ancient Greeks to the taxonomies proposed in the late 19th and 20th centuries, the models of temperament evolved historically in composition and character. Amongst others, Plato spoke of anxiety and impulsivity; Galen and Hippocrates believed in the sanguine, phlegmatic, melancholic, and choleric; Norman and Goldberg created the Big-Five; Eysenck defined the Big-Three, Strelau expanded on the dimensions of the Pavlovian nervous system, and Gray introduced neoPavlovian concepts to temperament research (Simonov & Ershov 1984/1991; Strelau, 1991).

The component building blocks of these models have included a maximum of 16, seven, five, and three factors (Cattell, 1971; Costa & McCrae, 1985; Eysenck, 1991). In addition, there are some theorists building on existing models and using factors that are common (Buss & Plomin, 1984) and others who propose alternative factors (Mehrabian, 1991; Zuckerman & Como, 1983). Theories of trait or type dominate the literature on temperament, with the distinguishing feature between them being a normal distribution for characteristics of trait and a bimodal distribution for characters of type (Eysenck, 1966). Although not discussed in this chapter, it is worth noting that temperament researchers who study children tend to distinguish between temperament and personality, and their models reflect more specific traits as opposed to the superfactors that represent broader and more general dispositions (Chess & Thomas, 1991; Talwar et al., 1991).

The relation of these superfactors or types to temperament depends on how the theorist perceives the relationship between temperament and personality. The preceding discussion implies that those who perceive personality and temperament to be synonymous (Eysenck, Gray, and Mehrabian) would merely describe temperament as reflecting the same dimensions of personality.

Theorists in the west and in Eastern Europe have proposed numerous approaches and models of temperament. Following the fundamental principles of arousal theory, which has its roots in the Pavlovian approach, Eysenck, Gray, and Strelau have proposed the PEN (psychoticism, extroversion, neuroticism), the neuropsychological, and the Regulative

Theory of Temperament approaches, respectively. These are characteristic reflections of neurobiologically based theories, arising from Western and Eastern European influences, which endorse a relationship between a descriptive taxonomy and explanatory theory (Stelmack, 1997).

Neurobiologically based theories draw on the fundamental assumptions endorsed by the Pavlovian notion of nervous system types and arousal mechanisms.

4.2.1 The Pavlovian influence

A revolutionary advancement in the study of the biological bases of individual differences was initiated through the work of Pavlov (Eysenck, 1987; Robertson, 1987; Simonov, 1987; Simonov & Ershov, 1984/1991; Zuckerman, 1987a). Beginning with applications of nervous types to the conditioned reflexes of dogs, Pavlov extended his theory to human personality. After observing conditioned reflexes, he concluded that types of nervous system activity are comparable to the temperament types described by Galen and Hippocrates, with specific aspects of emotionality characterising each type. Strelau, Angleitner, Bantelmann, and Ruch (1990) argue that Pavlov provided the most satisfactory biophysiological explanation of the Galen-Hippocratic types.

Pavlov's explanation of abnormal states in humans rests on the assumption that essential properties of the central nervous system can produce variations in behavioural and psychological outputs. Hence, the observed behaviour results from higher brain activity and the individual differences seen in this behavioural output are traceable to differences in a person's brain functioning. On a microscopic level, the brain activities allude to the intensity, homeostasis, and mobility of nerve cell stimulation and inhibition.

4.2.1.1 Nervous system types

The human brain, according to this theory, differs in specific fundamental properties that relate to strength or the capacity of the nervous system to endure intense stimulation. To account for the variability of responses to stimuli, Pavlov had to incorporate two opposing brain processes into his theory namely excitation and inhibition. The effectiveness of these processes depends on the endogenous differences in strength and this differential essentially maintains a balance between strength of excitation and strength of inhibition. In some instances, the excitatory and inhibitory processes are equal and in others, the excitatory processes are strong and inhibitory processes are weak.

These differences are related systematically to differences in behaviour that are classified according to type, for example, a sanguine temperament associated with a strong nervous system and a melancholic type related to a weak nervous system characterised by inhibition. A strong nervous system is also characterised by other properties such as mobility. This property determines the speed at which an individual can adopt specific appropriate responses to environmental stimuli. Thus, mobility underscores the adaptive capabilities of a person. Pavlov's classification confers both on the sanguine and phlegmatic type strong excitatory processes that are balanced by strong inhibitory processes. It seems that the differentiation lies in the third property, namely the mobility of the nervous system (Strelau, 1983).

Using the parameters of strength, equilibrium, and mobility, Pavlov extended his theory to include a higher order of central nervous system functioning. The intervening link between micro activity and overt behaviour lies in the reciprocal interaction of macro structures, which represents functionally distinct regions of the brain. For example, he associates the functional specialisation of the neocortical and the subcortical areas with the intellectual and artistic type, respectively.

4.2.1.2 Nervous systems properties, arousal and temperament

The Russian researchers (Nebylitsyn and Teplov) adapted Pavlov's theories and suggested that characterisations of the nervous system based on the Galen –Hippocrates types, revert to characterisations based on properties of the nervous system (Simonov, 1987). Eysenck's model shares theoretical foundations with that of the Pavlovian/neo-Pavlovian approach to temperament. The strength of nervous system functioning has similarities with the concept of arousal. For example, a strong nervous system requires more intense arousal than a weak nervous system because the latter is quickly aroused. The interaction of the ascending reticular formation with frontal neocortical areas determines the strength properties of the central nervous system, and this relates to extraversion and introversion. Gray (1981) modified Eysenck's ideas, added the hippocampus and septal area to the neuroanatomical scheme, and related a strong nervous system with extroversion and a weak nervous system with introversion.

In summary, Pavlov identified three fundamental properties of the central nervous system that determined individual differences in temperament. The ability to withstand intense and persistent stimulation without exhibiting protective inhibition, the ability to evoke and preserve a state of conditioned inhibition, and the response capabilities of the central nervous system to continuous alterations in the environment (Simonov & Ershov, 1984/1991; Strelau et al, 1990; Strelau & Zawadzki, 1993). The links between Pavlovian and neo-Pavlovian concepts are evident in the similarities between strength of nervous system, arousability, and temperament dimensions such as extraversion and introversion.

4.2.2 Temperament and arousal

The biological mechanism of arousal is considered one of the essential factors mediating temperament. The Pavlovian idea of arousal is associated with the excitatory mechanisms of the central nervous system that involves excitatory process, stimulus intensity, and transmarginal inhibition (Eysenck, 1970). The first premise underlying Pavlovian arousal entertains the idea that the intensity of stimuli determines the intensity of excitation, and the second premise holds that at a set point excitation translates into transmarginal inhibition. In other words, the intensity of actions is equitable with the level of arousal or excitation, and performance or reaction would decrease at levels of arousal that transcend the critical point.

In Strelau's (1987b) theory, the idea of optimal levels is used to determine how different temperaments weigh intrinsic and extrinsic stimulation in order to regulate the stimulus and moderate the response. Eysenck (1966, 1970) adopts the concept of optimal level of performance to explain the relationship between reactions and temperament characteristics. For example, extroverts have a low level of arousal hence, a high optimal setpoint. Another aspect governing the laws of arousal is the non-linear inverted U relation between performance and arousal (Yerkes-Dobson law), which implies that optimum levels are a function of the complexity and difficulty of tasks and situations. Easy tasks have a high level and challenging tasks a low level of arousal. Any stimulus that evokes levels beneath and beyond the optimum will impair performance.

Geen (1984) found that introverts choose a lower noise level than extroverts do, and both groups show no difference in arousal and performance when the noise levels were set at the preferred point. This result suggests that optimal performances occur when stimulation is at an appropriate critical point, and supports the Yerkes-Dobson law. Amelang and Ullwer (1991) explain that although extroverts occupy positions near the inhibition pole and introverts occupy positions near the excitatory end, both participants perform equally at optimum levels because of this protective mechanism that counteracts further arousal.

Eysenck (1966) differentiates between cortical arousal and autonomic arousal (activation), with the former tied to extraversion-introversion and the latter to neuroticism. Cortical arousal is tied to the cortico-reticular loop and autonomic arousal represents the functioning of the autonomic nervous system and hypothalamic activity (Eysenck, 1966). The limbic system (visceral brain) together with the hypothalamus forms the central circuit of emotion (Kalat, 2001). Gray (1991) expands on the neuroanatomical correlates by proposing distinct systems that regulate arousal mechanisms and stimulus sensitivities such as reward and punishment. The states (emotional construct) and processes of an individual determine the level of cortical arousal. Cortical arousal and activation, therefore relate to each other in complex ways.

To distinguish his idea from that of Eysenck and others, Gray (1991) expands on the meanings of arousal by using terms such as determinants, indices, and determinates. His theory focuses on determinates (signal sensitivity) and specific types of arousal, whereas Eysenck focuses on the determinant (conditionability) and general arousal. The implication of this distinction is that Gray's idea of arousal is associated more with neuroticism than with extraversion and the extraversion-introversion continuum represents a balance between sensitivity and arousability. Strelau, on the other hand is regarded as a general arousal theorist because of his contention that many physiological mechanisms engaging with energy storage and release processes underlie the trait of reactivity (Zuckerman, 1987b). The dominance of any one system is dependent on the task and situation and differences exist in the biophysiological arousal processes responsible for reactivity. Arousal as a physiological and psychological construct, therefore integrates many of the approaches discussed in this chapter.

4.2.3 The PEN model

The PEN model serves as a biologically based explanation of interindividual differences in personality and temperament. This structural model of the phenotypic traits was derived from the seminal work of Hans Eysenck (1966, 1987). The three factors identified by Eysenck include psychoticism, neuroticism, and extraversion, and these are believed to have strong biological roots in which arousal, visceral brain activation, and hormones actuate the three dimensions, respectively.

The two components of the model are the state–trait distinction and the taxonomic theory. The former allows for a distinction between a relatively permanent disposition (trait) and a transitory intrinsic condition (state). At the core of this structural framework is a hierarchical taxonomy of temperament containing four levels of behavioural organisation (Eysenck, 1997). At the lowest level are simple behaviours that occur at a single moment. At the next level are habits or recurring behaviours, and the third level contains traits or factors, which are developed from interrelated sets of habits. The highest level contains the orthogonal superfactors (P, E, N), which are comprised of constellations of traits.

Eysenck (1966) suggests that level three and four denote types and traits of temperament, respectively. Thus, the hierarchy represents a type (e.g., extraversion) and a trait (e.g., social activity). The emphasis is on the dimensional rather than categorical aspects of temperament. For example, the model allows individuals to have some degree of P, E, or N on a co-linear continuum rather than an all or nothing score on the factors. The empirical validation and universal appeal of the tripartite model has been demonstrated across many countries. Evidence for this comes from cross-cultural studies in which data was analysed from 25 countries spanning seven continents (Barret & Eysenck, 1984). The analysis revealed significantly identical factors with a factor comparison that averaged .98. Eysenck's (1991) key conclusion from this study was that biological mechanisms such as arousal and activation serve as the main determinants of temperament.

A similarity exits between Eysenck's ideas of activation and arousal, system activities that vary in strength and synergistic rhythms, and the Pavlovian idea of the strength of nervous system (Fahrenberg, 1991; Newberry et al., 1997). By combining the extraversion and neuroticism dimension one can, for example, equate the sanguine with the stable extrovert, the phlegmatic with the stable introvert, the choleric with the unstable extrovert, and the melancholic with the unstable introvert. Furthermore, extroverts have low arousal patterns and slow/weak generation of excitatory potentials or in Pavlovian terms a strong nervous system, whereas introverts have high arousal patterns and quick/strong reactive inhibitions or weak nervous systems (Eysenck, 1970; Robertson, 1987). The latter represents the Pavlovian sanguine type and the former the phlegmatic type.

Therefore, Eysenck's PEN structure contains three dimensions and the individual differences in these dimensions are attributable to the notion of arousal and activation with extraversion associated with arousal and neuroticism linked to activation.

4.2.3.1 The PEN dimensions and biological substrates

In comparison with other proposed dimensions, neuroticism and extraversion have limited invariance in factor analyses and high validity estimates in predicting peer ratings (Amelang & Ullwer, 1991). In addition, they derive support from specific theories that enable them to transcend the purely descriptive levels assigned to other dimensions. The achievement of this lofty status comes from empirical evidence of a strong neuroanatomical bases for the variance observed amongst individuals displaying these dispositions. The following sections will elaborate on the anatomical and physiological mechanisms underlying the extraversion and neuroticism dimensions.

4.2.3.2 Extraversion and arousal

The biological parallel for the extraversion dimension is the activity level of the cortico-reticular loop. It is important to note the afferent and efferent connections to the cortico-reticular loop because these pathways are susceptible to the degenerating effects of aging and Alzheimer’s disease. The cortico-reticular loop is part of the ascending reticular activating system, it is responsible for functions such as attention and arousal, and is regulated by the brainstem and parts of the thalamus (Woodruff-Pak, 1997). The subcortical structures are responsible for oscillations in rhythmic arousal patterns and the cortical frontal systems are responsible for the inhibitory control of the reticular system. Consequently, the neocortex imposes a restraint on the subcortical areas so that cortical excitation (high efficacy of cortex) would manifest as decrease in extraversion and an increase in introversion.

Inhibition of cortical activity, on the contrary, would release lower centres from control and result in an increase in extraversion and a decrease in Introversion. Neural impulses, according to Eysenck (1970), travel to projection areas in the cortex and to the reticular formation. The established reciprocity between the reticular formation and cortex occurs when arousal messages are sent from the reticular formation to the cortex and the cortex instructs the reticular formation to continue with the excitatory impulses or to switch to inhibition. The feedback loop is the nerve centre for arousal and according to the arousal theory its functioning explains the difference between extroverts and introverts. Eysenck (1970) equates the activity of the cortico-reticular loop to the construct of cortical arousal.

Introverts, according to Eysenck (1970) have a higher level of arousal than extroverts do because extraversion is a derivative of the slow functioning of the ascending reticular activating system. His theory rests on the presumption of hereditary components that determine the association between excitatory and inhibitory processes in the nervous system. Thus, position on the excitation-inhibition continuum would determine whether an individual is an extrovert or an introvert.

The optimal levels of arousal according to this theory differ for introverts and extroverts because of the difference in general arousal levels. Introverts can tolerate less intense arousal than extroverts can because the latter begin with a higher threshold. The introvert's neocortex exerts more inhibition on the subcortex, and the introvert displays more inhibited behaviour than an extrovert because of this biological mechanism. Support for this hypothesis comes from recent studies that showed arousal to be associated more with the impulsivity rather than the sociability component of extraversion (Revelle, 1997).

There has been some disagreement on the association between arousal and extraversion, and part of the problem lies in the inconsistent operationalisation of theoretical constructs such as arousal (Fahrenberg, 1991). Several investigators measured EEG recordings of extroverts and introverts and found that extraversion was not associated with arousal but rather that persons with a high psychoticism score have low cortical arousal (O'Gorman & Lloyd, 1987). In a study of respondents with high and low psychoticism scores, Robinson and Zahn (1985) found that high psychoticism scorers manifested with physiological hypo-responsiveness, which indicated a low arousal level.

Another criticism of the extraversion-arousal relationship deals with the limited scope of the theory, which deals exclusively with cortical arousal. Researchers found that the motor neuronal reflex decreases in persons with high scores on extraversion and the Disinhibition scale. This implies that arousal theory can include subcortical involvement and the result that lower subcortical excitability is associated with temperament may suggest a link with biochemical markers particularly dopamine (Pivik, Stelmark, & Bylsma, 1988). Introverts and extroverts differ on performance tasks when subjected to a drug that mediates movement and reaction time through inhibitory effects on dopamine synthesis, with the drug increasing movement and reaction time for introverts but not extroverts. These results attest to the contribution of dopaminergic activity and subcortical arousal as an important determinant of individual differences in the extraversion domain (Stelmack, 1997).

4.2.3.3 Neuroticism and activation

The regions associated with neuroticism include the limbic area and the autonomic nervous system, which is responsible for the expression of emotionality via arousal of the ascending reticular activating system. More specifically, activities of the visceral brain (sympathetic nervous system), which includes the hippocampus, amygdala, striatum, septum, and hypothalamus, mediate neuroticism. These structures regulate important functions and their idiosyncratic levels of activation and action thresholds determine output of emotional and biological states. Linked to emotionality/neuroticism is an information pathway that forms when the visceral brain sends messages to the reticular formation and arouses the cortex via the ascending reticular activating system. This mechanism is referred to as activation and individuals with high scores on neuroticism have greater activation levels and lower excitation thresholds in the visceral brain (Eysenck, 1991). In other words, they are more susceptible to psychological distress.

The biological explanation gains favour when one considers the interaction between the two systems implicated in extraversion and neuroticism. Eysenck (1966, 1970) demonstrated that subjects who had high neuroticism scores showed an inverse correlation between extraversion and neuroticism. He assumed that the ascending reticular activating system arousal (cortical) does not affect limbic activation (autonomic), but the latter causes an increase in reticular and cortical arousal. This implies that cortical arousal occurs without any autonomic-emotional arousal whereas autonomic nervous system activity involves the hypothalamus and amydala and mediates cortical arousal processes. Although arousal depends on impulses travelling through two loops, there is a degree of independence between the two loops, with the activation loop producing arousal, but the arousal loop bypassing the activation loop.

4.2.3.4 Neuroticism and anatomical asymmetry

The biological theory of neuroticism as postulated by Eysenck is not conclusive and other researchers have attempted to expand on the search for biological roots. One such attempt by Tomarken and Keener (1998) indicates that differences in frontal cortex activity amongst persons who displayed negative and positive affective traits, which represented aspects of neuroticism and extraversion, could be linked to brain asymmetry. They found that individuals with negative traits displayed more right frontal activity, and left prefrontal rest activity was evident in persons with positive traits. They conclude that prefrontal activity appears to be associated with disposition.

This anatomical asymmetry underlies the actions of neurotransmitters, and this link between asymmetry and neurotransmitters provides support for Eysenck's (1970) contention that disposition is the result of the interplay between heritable features. Temperament, for example, has been linked to monoamine systems (Zuckerman, 1991) and these nuclei have ascending projections to the frontal areas (Kalat, 2001). Research on schizophrenic patients has shown that dopamine is linked to positive affect and this is corroborated by anatomical studies that show a distinct asymmetry in the frontal cortex with more dopamine nuclei in the left prefrontal area (Cohen & Servan-Schreiber, 1992; Lezak, 1995).

In sum, the Pavlovian concept of excitation-inhibition has been used in a general sense by Eysenck to distinguish arousal and activation patterns of the temperament types he proposed. The structure of his model follows a top-down approach where he defined the basic traits and thereafter investigated their occurrence in behaviour, and associated differences in physiological mechanisms to different personality types.

4.2.4 A neuropsychological approach

Gray (1981) concurs with the idea of a hierarchical taxonomy of temperament, but unlike Eysenck's top-down approach, his research represents the bottom-up approach. He postulates on the biological substrates of behaviour that he derived from lesioning studies and brain stimulation investigations, and extends the results to human behaviour, thus following a botttom-up approach in the construction of his model.

Gray disagrees with two fundamental notions of Eysenck: the notion that extraversion and neuroticism are the only potential candidates defining human temperament, and the idea that optimal level of arousal was the only construct explaining individual differences. He adapts the latter construct to form a bridge between his neo-Pavlovian theory and Eysenckian concepts.

In Gray's (1981, 1991) reformulation of his reinforcement-sensitivity theory, impulsivity and anxiety adopt positions on the fundamental axes of personality. Extroversion and neuroticism, according to this theory, are merely distal consequences of the interaction between anxiety and impulsivity. This reformulation proposes that neuroticism and extraversion are underscored by the reactivity differences in two distinct anatomical regions (Gray & McNaughton, 2000). Non-reward and punishment sensitive reactivity in one region determines trait anxiety, and reward and non-punishment sensitive reactivity in the other region determines impulsivity.

The key element in this model is emotion and its definition as a transitory position evoked by reinforcing stimuli or situations that mediate functional behaviour (Mehrabian, 1991). From this starting point, Gray postulates that three emotional states exist that collaborate with specific reinforcers and respond with specific behaviours. Furthermore, the emotional states have corresponding neuroanatomical structures that underlie specific information processing mechanisms. Gray's theory is based on the postulate that all psychological functions depend on brain activity, and if there is a psychology of temperament then there has to be a neuropsychology of temperament, which attests to the relationship between brain and behaviour.

4.2.4.1 The divergence between Gray and Eysenck

The first divergence in the Gray and Eysenck models involves the trait of impulsivity. Gray assumes it is a defining trait, whereas Eysenck and Eysenck (1985) reformulated their theory and moved impulsivity from the extraversion domain to the psychoticism dimension, with sociability replacing it under its former dimension. However, several studies show that the inclusion of impulsivity rather than sociability as an extraversion trait made more anatomical sense because impulsivity was associated with ascending reticular activating system mediated diurnal arousal patterns, and as an energetic aspect of extraversion it is related to the excitation-inhibition balance (Amelang & Ullwer, 1991).

In a review of several studies, which included psychopharmacological experiments and motor and visual reactivity tasks, Amelang and Ullwer (1991) reiterate that sociability has an insignificant association with the arousal theory of extraversion, and this theory of extraversion is based on the trait of impulsivity as the main component of extraversion. According to available data, impulsivity is the trait responsible for the observed differences amongst introverts and extroverts in experimental and psychophysiological activities.

The second divergence is Gray's revision of the arousability construct. He defined arousal as a function of separate biological factors determining individual differences in response to reward and punishment, as opposed to Eysenck's general notion of arousal, which explains the relationship between performance and position on a particular dimension. The sites and expressions of these biological systems are separate and different. Activity in the behavioural inhibition system (hippocampal formation, Papez circuit, and septal region) is associated with anxiety traits and in turn to signals of punishment and non-reward. The flight/fight system (amygdala and central gray matter) is activated by unconditioned stimuli such as punishment, and the output behaviour tends to be defensive aggression or escape behaviour. Lastly, the behavioural approach system (basal ganglia, ascending dopaminergic fibers, thalamic nuclei, and neocortical areas) is responsive to reward or cessation of punishment and has been tentatively linked to conditions such as impulsivity, happiness, elation, and hope.

4.2.4.2 Gray's challenge to the general arousal hypothesis

The association between emotional systems and temperament lies in the role of temperament as a mediator of operations and enforcer of boundary attributes for the three emotional systems. According to Gray (1981) an individual who contains a more robust behavioural inhibition system of anxiety than a behavioural activation system of impulsivity is most likely be introverted, and one who contains a more powerful behavioural activation system of impulsivity as opposed to a behavioural inhibition system of anxiety may become extroverted. Therefore, neuroticism and extraversion cannot be superfactors because they are derived from the interplay between the emotional systems rooted in brain structures, and not merely from differences in arousal and activation thresholds.

Gray's theory, moreover, introduces the idea of biologically based sensitivities to positive and negative signals and the extroversion-introversion dimension represents the balance between the sensitivities and arousability (Zuckerman, 1987a).

In an attempt to understand how the differential functioning of these systems correspond to personality traits described by Eysenck, learning and performance were assessed in introverts and extroverts using positive and negative reinforcers. Gray (1991) predicts results that oppose Eysenck's formulations. He established that introverts were more likely to learn when the reinforcement was negative, whereas Eysenck's formulations would favour the reverse. The latter is understandable, since negative reinforcement is more arousing and should according to Eysenck's arousal theory facilitate the performance of extroverts.

Although Gray's findings showed a contrast between the two postulations of temperament, the emotional models are speculatively useful for confirmation of the arousal hypothesis underlying Eysenck's model. The level of arousal of an individual is attributable to the comparative balance between the behavioural inhibition system and behavioural activation system and the negative reinforcers are more arousing than positive reinforcers. It follows that a negative reinforcer would augment the arousal level of a person with a higher sensitivity to it (introvert) than to a person who is more sensitive to positive reinforcement (extrovert). Thus, introverts are at a higher level of arousal than extroverts because of the different reactivity thresholds of their behavioural inhibition system and behavioural activation system.

A further challenge to the general arousability hypothesis came from the results of a study using caffeine as a stimulant. Revelle, Humphreys, Simons, and Gilliland (1980) establish that small doses of caffeine affected the performance of introverts and aided the feat of extroverts. However, this result was influenced by diurnal arousal patterns and impulsivity. In the morning, individuals with low impulsivity showed a negative reaction and high impulsives a positive reaction to caffeine.

This result implies that arousal levels between low and high impulsives fluctuate and the groups differ in accordance with the diurnal cycles instead of over-and under-arousal, respectively. Introverts were more aroused in the morning and extroverts in the afternoon. Anatomically this makes sense because the ascending reticular activating system, which regulates patterns of arousal and attention, is also involved in sleep-wake cycles (Kiernan, 1998). Findings of this nature highlight the situational influences on arousal, and challenge the general principles of the arousal theory by questioning the assumption that extroverts are always less aroused than introverts.

Gray challenges the important principles of Eysenck's theory, however, Eysenck's theory forms the basis of the neuropsychological theory of temperament. Moreover, additional research is needed to verify the structures that comprise the emotional systems (behavioural and fight/flight systems), and their contribution to individual differences in temperament.

4.2.5 A unification of Gray and Eysenck: Cartesian theory

A three-axis orthogonal theory forms the structure of Eysenck's PEN model. Hammond (1994) argues that the principles of an axiomatic theory and its application of a Cartesian division on human form could help establish the neurobiological roots of P, E, and N. The presupposition of a three-axial division allows for the central nervous system and spinal cord, the central fissure, and the medial fissure to represent basic Cartesian geometry. This Cartesian structure evolves through the handiwork of nature during mitotic and embryological processes. Moreover, the tri-axial anatomical design shows marked differentiations on each axis namely the neuroaxial formation (stem-limbic area), the Bell-Magendie crossover, and Sperrian lateralisation (Hammond, 1994).

According to Iverson, Kupfermann, and Kandel (2000) the concept of the limbic system (first axis) underwent a considerable expansion because of the work of Maclean, who revised the Papez system and included structures such as hypothalamus, septal area, nucleus accumbens, neocortical regions and most importantly the amydala, which is a key player in the neural circuitry of emotion. The Bell-Magendie law states that entering dorsal roots carry sensory information and departing ventral roots carry motor information to muscles and glands (Kalat, 2001). Thus, the central axis (central Rolandic fissure) cleaves the brain dorso-ventrally because it has the Bell-Magendie differentiation on either side of it.

The last axis imposes a relatively bilateral symmetry on the brain. An important discovery that all mental functions are divisable into subfunctions composed of various independent information processing components advanced the idea of functional lateralisation, the underlying idea being that mental processes have a modular nature because they require the co-ordination of several distinct brain areas (Kandel, 2000). Sperry (cited in Kalat, 2001) is one of the first researchers to provide evidence for the localisation of function by demonstrating the specificity of axonal connections during regeneration and he is also commended for identifying the neuropsychological function of the medial axis. Adding to his work on spilt-brain patients, Gazzinaga (1987) found that in commissurotomised patients each hemisphere processes information and responds independently from the other, and each hemisphere is dominant for a specific higher cognitive function.

Based on the Cartesian differentiation, Hammond (1994) suggests that the neuroticism, extraversion, and psychoticism continuums represent the Sperrian lateralisation, the Bell-Magendie function, and the neuroaxis, respectively. He contends further that this would also support Eysenck's idea that extraversion, neuroticism, and psychoticism reflect processes of cortical arousal, limbic activation, and neuroaxial modulation via the ascending reticular activating systems, respectively. Gray's model of emotional subsystems is reflected as a neurologically connecting design that directly associates the diagonally positioned lobes of the brain and creates, in addition to Eysenck's personality axes, a set of diagonal axes of personality (Hammond, 1994).

Gray's behavioural inhibition system is responsible for states of anxiety and impulsivity. The main function of the septohippocampal system is to act as a comparator and enforce behavioural inhibition. Exterceptive sensory input is compared to predicted or expected events generated by interoceptive sensory input travelling through the Papez circuit. If the comparator detects a discrepancy between the two it creates a reactive state of anxiety (Gray & McNaughton, 2000). Hammond (1994) argues that the septo-hippocampal system has a decussation and thus follows the Bell-Magendie division of a dorsal-ventral symmetry and a bilateral symmetry. The latter suggests that the left hippocampi control the anxiety factor and the right hippocampi control the impulsivity factor.

A unification of Eysenck's and Gray's theories can only be successful if Cartesian principles are applied to the conceptions of causality. The extraversion and neuroticism factors appear to have positions in the four lobes of the brain as evidenced by the bilateral division of the medial fissure and the central fissure's dorsoventral division. Gray's comparator collates information or expectations from the four lobes and they provide highly processed information into the Papez circuit. The unification is complete if one perceives Gray's "diagonal system as a mediator of personality conflict …and as a functional corollary to the underlying Eysenckian structure of personality" (Hammond, 1994, p. 4). Therefore, the Cartesian theory implies that there are three neuropsychologically founded axes in the structural design of personality, and two concurrent neurologically founded axes of personality conflict. This design yields a five-factor model based on anatomical differentiation.

The neuropsychological approach to temperament has yielded insightful associations between temperament dimensions and specific neuroanatomical systems. On the one hand, it provides a framework from which clinical symptoms of neurological impairment can be approximated. A necessary caution, however, is that the functioning and components of the behavioural activation and behavioural inhibition systems and their link to specific temperament traits have been subjected to limited scrutiny because of the specificity of the neuronal systems involved. Strelau (1991) accepts Gray's premise of temperament as a function of its neuromodular interactions, but suggests that the neuroanatomical bases are not specific and the regulation of temperament involves the functioning of many complicated systems.

4.2.6 The Regulative Theory of Temperament

Most of the authors that follow the Pavlovian or neo-Pavlovian tradition spurn the constitutional approach to temperament and its accompanying trend of using temperament and personality synonymously (Strelau, 1991, 1987c). The division between the Eastern

European, American, and British researchers is reflected in the work on temperament from each region. There exists a differential focus on biophysiological mechanisms, social influences, experimental studies, clinical studies, paper-pencil techniques, and target populations (children and adults), with researchers in East Europe focusing on biological causation, experiments, and adult populations.

Strelau (1983) developed the Regulative Theory of Temperament and based it on the principles derived from both eastern and western influences. According to Strelau and Zawadzki (1995) many theories and descriptions of temperament serve as a source for the structure of the Regulative Theory of Temperament. The Pavlovian typology, the characterisations of the 1800's when temperament was described as strength and changeability of disposition, and the characterisation of the 1900's when temperament was seen as a dynamic feature of activity, provided rich sources of data for the development of this theory. The underlying motivation for its development comes from the realisation that traditional views of arousal or activation levels are of little value in understanding systematic interindividual differences in behaviour (Klonowicz, 1987). Moreover, the Regulative Theory of Temperament imbues the idea that stable differences in arousal exist between people and this is evident in the variable stimulation-processing coefficients that drive individual styles of behaviour.

The Regulative Theory of Temperament begins with a conceptualisation of temperament not as the content of behaviour but rather as a reflection of formal aspects of behaviour. In other words, temperament has no content and is not directly responsible for the content of behaviour. Dual levels comprising the energetic and temporal aspects mediate its effects on the form of behavioural output.

4.2.6.1 Energy level

An energy system allows humans to exchange energy with the environment, learn from these exchanges, and ultimately interact with efficiency to conserve energy. This process works in a systemic way and involves exchange, transmission, feedback, and control mechanisms.

In order to relate this to the idea of individual differences in temperament, the energy system has to be perceived as a four-component structure comprising acquisition, expression, storage, and monitoring elements (Gale, 1987). Energy acquisition follows a slow or quick and frequent or rare path. Imbued energy derives from either a few or many sources. The acquisition differentials mediated by the functioning of the acquisition system are observable in behaviour. For example, extroverts would likely have a busy acquisition system (intense, frequent, and varied energy exchanges). The expression system in extroverts is characterised by high motor displays that require intense energy conversion and output. Efficient and inefficient storage systems are able to either store and distribute energy to appropriate behaviours or waste energy output, respectively. An individual high in neuroticism would seem to have an inefficient storage system.

Each of the systems operate with a monitoring system that works towards efficiency, however, depending on the temperament of an individual the control system would focus on different things and maintain differential thresholds. In other words, extroverts and introverts have an efficient expression and acquisition system but the latter functions at a low threshold and the former at a high threshold. However, the control system of the extrovert is biased towards expression (high output), and the control system of the introvert towards acquisition (low input). Therefore, the interaction of these four energy level systems accounts for the differences observed in behaviour.

Three anatomical systems determine the energetic features of temperament (Simonov, 1987; Strelau. 1987b). These include the neuroendocrine system, the ascending reticular formation (neocortex-hypothalamus-hippocampus-amygdala system), and the frontal cortex.

The energetic level has two dimensions that are responsible for individual differences namely reactivity and activity. The former resembles the Pavlovian concept of strength of excitation, is measured by intensity or magnitude of reactions to stimuli, and is a direct aspect of temperament. Sensory sensitivity and endurance combine to form a reactivity construct that is psychological and behavioural in nature, and involves primarily nonemotional reaction phenomena with emotional responses secondary to this (Zuckerman, 1987). The three ways in which reactivity influences a person's activities are as follows (Schulz, 1986):

- In stressful conditions reactivity influences performance.
- A person's style of behaviour is moderated by reactivity.
- Reactivity modulates individual performances for various situations according to their stimulus properties.

Klonowicz (1986), using the arguments of Teplov and Strelau, states that the stable individual differences observed in the organisation of goal-directed activity have their origin in a person's individual style of behaviour (reactivity). The two extremes are high reactivity (high sensitivity, low endurance) and low reactivity (low sensitivity, high endurance), which are governed by the physiological mechanism underlying stimulation processing. For example, a high stimulation-processing coefficient correlates with high reactivity and a low stimulation-processing coefficient with low reactivity. Furthermore, it seems that reactivity controls the levels of arousal by acting as a filter for environmental stimuli that have arousal potentials (Eliasz, 1987). Hence, as a temperament dimension it influences the acquisition, storage, expression, and control of energy levels.

Activity, on the other hand, pertains to goal directed behaviour that is characterised by a specific stimulus value, specifically the amount and range of the behaviour undertaken. According to Strelau and Zawadzki (1995), most temperament theories consider activity to be a motor feature. However, activity can be related to many features manifested in social situations and has associations with motor behaviour as well as with extraversion and sensation seeking. The stimulation for activity can arise from a number of sources both extrinsic and intrinsic. External sources would include events, tasks, or environment, and internal sources include behaviour, emotions, and idiosyncratic reactions.

An individual's optimal level of arousal and level of reactivity co-determines the regulation of activity. Furthermore, there is an inverse relationship between reactivity and activity. For example, individuals with high reactivity and a low optimal arousal set point (introverts) are less likely to be active than individuals with low reactivity and a high optimum arousal set point (extroverts). Therefore, persons with high reactivity have complex biophysiological processes that augment stimulation, whereas low-reactives have processes that repress stimulation. Due to this difference in activity levels that arise from the expression system, persons with high reactivity have control systems that monitor input sources and low reactives have control systems that monitor output because of their tendency for increased activity and energy expansion (Gale, 1987; Strelau, 1994). The following table outlines the three main differences between reactivity and activity (Schönplug & Mündelein, 1986):

Table 4-2 Differences between reactivity and activity (Schönplug & Mündelein, 1986):

Reactivity	Activity
Situation dependent (input)	Goal-directed (output)
Stereotyped	Flexible (adaptive)
Reaction = situation (bound to the present)	Activity = adaptation (future directed)

4.2.6.2 Temporal level

Five temperament traits, according to the Regulative Theory of Temperament, represent the temporal level of behaviour. These include mobility, persistence, recurrence, regularity, speed of reaction, and tempo of reaction. In comparison to the research on energetic aspects, the temporal dimensions are underscored by limited scrutiny. The temporal aspects represent the mobility of the nervous system, as characterised in Pavlov's typology. The five characteristics are defined as:

- *Mobility*: refers to an individual's flexibility in changing behaviour according to changes in the environment. A positive correlation exits between mobility and strength of excitation.
- *Speed*: involves the idiosyncratic reactions to stimuli. The impulsivity dimension contains this characteristic.
- *Tempo*: refers to the frequency of stereotyped reactions within a time frame

- *Recurrence*: characterised by repetitive reactions after termination of stimuli.
- *Perseverance*: refers to the maintenance of reactions after stimulus termination.

Strelau and Zawadzki (1995) outline three reasons for the separation inherent in their structure of temperament. Firstly, intensity of behaviour and speed of reaction underlie separate functions. Secondly, the biophysiological substrates of temporal and energetic components are distinct. Thirdly, temperament is characterised on a level of primary traits and the dual structure of Regulative Theory of Temperament allows for the specificity of these characteristics to be highlighted.

4.2.6.3 Summary

The Regulative Theory of Temperament as proposed by Strelau (1983, 1987c) identified dimensions relating to the style of behaviour thus, providing a definitional component of temperament. In its opposition to personality, temperament in this approach pertains solely to aspects that modify and regulate behaviour as well as to the way behaviour expresses itself. Temperament manages these processes by regulating reaction levels proportionate to exogenous stimulative and endogenous activity values.

The PEN model, Gray's neuropsychological approach, and Strelau's theory all postulate on the neurobiological basis of temperament. The inherent differences among them often stem from the varied conceptualisations of arousal and its relationship with disposition. Arousal has been conceived as a drive, stimulation source, stimulation concomitant, trait quality, or as an individual difference trait (Gale, 1987). However, whether these theories consider arousal as a state or trait measure, they endorse the idea that process is more important than outcome. Two individuals, with distinct scores on the neuroticism scale may behave in similar ways but achieve that outcome through different routes. The neurodynamic approach to temperament endorses the emphasis on process and considers temperament or disposition as a function of probabilistic neural processes.

4.2.7 A neurodynamic view of temperament

Before embarking on a discussion of this nature, clarification of a contentious point is necessary. This deals with the vociferous protests of traditional psychological thinkers who believe that neuroscience is attempting to map the language and processes of the brain onto the territory of psychology or the mind, and from this believe they garner the accusation of improbable reductionism. An accusation of reductionism only holds true if one believes that there is a perfect fit between molecular and neural activity and brain states. However, knowledge of both psychology and neuroscience reveals that there are no perfect fits, only probabilistic associations between molecular/neural processes and psychological activity. These probabilistic equations allow for novel ways of understanding and evaluating psychological phenomena in the context of neural science, without the agenda of conquest and extinction of one discipline for another. .

The science of neurodynamics is the study of neural processes with the understanding that processes characterise structure and emergent psychological activity. A neurodynamic view of temperament differs from the conventional stance that temperament is a reflection of dimensions or trait characteristics, and postulates that temperament is a process that affects the probabilities of neural functioning, and through this influence it is responsible for emergent psychological experience. It is thus a functional theory as opposed to a trait theory of temperament.

The roots of this functional theory can be traced to the discourses on cybernetics that were proposed by Bateson and Maturana and Varela (Capra, 1997). The computer/information processing model of cognition, which was dominated by notions of sequential processing and localisation, was replaced by the view that cognition is driven by structure, pattern, and process. The latter approach replaces notions of representation with connectivity, narrow conventions with global coherence, and information processing with emergent properties (Capra, 1997). This connectionist approach opens up new ways of perceiving temperament that opposes archaic notions of temperament composition.

4.2.7.1 Temperament as an emergent property

The following postulates underlie the neurodynamic view of temperament (Grigsby & Stevens, 2000):

- Temperament affects the activation probabilities of different neural systems.
- Temperament like *state* has no structure or content because it is an *emergent property* of a self-organising system.
- The self-organising system has the architecture of modular distributed hierarchy.
- Structure is equated with functions, which determine its potentialities and constraints.
- The stability of temperament arises from the neuropsychological constituents of temperament, which are relatively stable.
- In addition to genetics, other biological and environmental factors determine temperament.
- Dimensions of temperament are not just psychological constructs but reflect the activity of distributed neural systems.

Central to the understanding of this theory is the conception that temperament like state (a neurodynamic concept) is an emergent property. State is a

> complex, multidimensional control parameter influencing behaviour by affecting the probabilities associated with activation of specific neural networks, and influenced in turn on the biological level by the individual's psychological and behavioural activity (Grigsby & Stevens, 2000, p. 164).

Temperament, by sharing the status of emerging phenomena with state, would also share in this definition. Inherent in the definition is a reciprocity element that would allow the perception of temperament as genetically determined and influenced by other neural mechanisms and exogenous factors. Temperament as a neurodynamic concept shares attributes with conceptions of Zuckerman and Thomas and Chess thus transcending both the phenotypic-genotypic and the explanatory-descriptive divide. The following properties of state, as defined by Grigsby and Stevens, (2000), are applicable to the neurodynamic interpretation of temperament.

1. State is derived from nonlinear interactions between many subprocesses and it is an instantaneous and evolving process.
2. States determine the probabilities of activation of neural systems and on a psychological level determine the possibilities of certain dispositions in thought, affect, and behaviour.
3. States undergo oscillations and bifurcations.

These descriptions pertain to the nature of temperament. The probabilistic functioning of neurons reflects the consistency of a person's temperament. Descriptions (2) and (3) suggest that the shifting constitution of temperament on a microlevel may explain why certain temperament types show a larger amount of variability across time or situations.

The idea of functional systems and hierarchical processing, as espoused by the neurodynamic approach, has been explored in neuropsychological literature. A brief review of the principles and protagonists of theories of hierarchical functional systems, will be attempted in the following section

4.2.7.2 Underlying brain architecture

The idea of a hierarchical modular architecture is borrowed from the writings of Bastian (1902), theories of Luria (1966), and the works of neuroscientists, for example, Wernicke and Broca (cited in Kandell, 2000; Lezak, 1995; Martin, 1998). Luria (1966) states that a dynamic theory of localisation could not accommodate a narrow definition of localisation of function. He collated function with the idea of "functional systems" and " working mosaics", which is based on a "dynamic, complex constellation of connected systems at different levels of the central nervous system" (p. 23, p. 24). This view of function is systematic rather than concrete, implies that hierarchical relationships exist between different levels of the brain, and multilevel functioning is involved in mental processing of executive abilities. Therefore, neither function was envisaged as reflecting the activity of an organ or group of cells, nor localisation confined to particular parts of the brain or groups of cells. Instead, structure is synonymous with functional pluripotential implying successive and simultaneous stages rather than isolated static centres.

Wernicke discovered that only elementary processes were localised in specific parts of the brain and complex functions arose from the interactions between many functional areas.

Thus, mental functions were an aggregate of their sub functions with component processing representations in different areas. What followed from this discovery was the idea that processing had to be distributed and of a parallel and sequential nature. More recently the discoveries of Wernicke and Broca on language functions in the brain was confirmed through experiments on a conscious living individual (Calvin & Ojeman, 1994).

Neuropsychological studies have also shed some light on the general anatomical localisation of affective traits and personality. Kandel (2000) uses the example of temporal lobe epilepsy. The interictal phenomena accompanying this type of epilepsy shows distinctive personality traits in comparison to epilepsy patients with foci outside the temporal lobes. One of the key problems generated by a modular conception of functioning is the binding problem, which is as yet one of the unsolved mysteries of brain-behaviour relationships. This quagmire stems from the paradox inherent in the workings of a distributed functioning system and its ability to give rise to a cohesive sense of experience (Wurtz & Kandel, 2000).

From the theories of modularity and hierarchical processing, Grigsby and Stevens (2000) formulate the idea that personality or temperament is a modular, distributed, hierarchically organised system. As the first premise they adopt Luria's notion that functional systems comprise both structural and functional components and thus structure and function are synonymous. The second premise underscoring their theory involved equating the functioning systems of neuropsychological domains to neural functioning of temperament. If perceptual, motor, sensory, and cognitive functions can follow a modular organisation then according to them temperament is no different because it is also a psychological phenomenon that is an emergent property of functional systems.

4.2.7.3 Contributions of a novel view on temperament

Two important implications arise from a neurodynamic view of temperament. The first relates to the underlying hierarchical and modular functioning of neural systems. Because these systems act in either opposing or facilitatory ways with each other, features of temperament, which are an emerging property of this interaction, are not likely to be orthogonal in their relation to one another. The second relates to the notion of self-organising or self-regulating systems. Temperament arises from the interactions of such systems hence, optimal levels of arousal cannot account for the self-regulatory mechanisms of temperament inherent in this framework (Rothbart, Derryberry, & Posner, 1994). In comparison with the theories discussed above, the neurodynamic view of temperament discards the idea of orthogonal traits and arousal as the key dynamic determining temperament positioning.

The similarities between this theory and the Regulative Theory of Temperament lies it the conceptualisation of temperament as content free dispositions. It shares with the Pavlovian typology, a strong affinity for neurophysiological descriptions of concepts, and differs from the behavioural emphasis inherent in Strelau's Regulative Theory of Temperament. Unlike most other accounts of temperament, which are either trait or type theories, the neurodynamic view claims to be a functional theory of temperament and expands on the arousability hypothesis by considering the self-regulatory nature of neural systems.

4.2.8 An aside on the Big-Five

Unlike the PEN model, which includes both descriptive and causal elements in its theory, other trait theories such as the five-factor model is based on the lexical approach and adopts a descriptive framework (McCrae & Costa, 1987; Eysenck, 1997; Watson, 2000). This approach envisages natural language to have the engrams of essential traits because traits are the cornerstones of human relations. Therefore, analyses of language would provide the precursors of a structure of personality (McCrae & Costa, 1997).

4.2.8.1 A brief history of the Big-Five

According to its critics the crucial fragility of this framework as a scientific explanation lies in its disregard for casual relations and its inductive as opposed to hypothetico-deductive approach to identifying temperament or personality dimensions (Eysenck, 1997). Although the five-factor model is hierarchical, it does not differentiate between levels as rigorously as the three-factor model. Moreover, the structural framework of the five-factor approach is more inclusive than other trait theories, includes cognitive referents, and regards intellectual process and emotional processes as components of temperament. For example, at the top level of the pyramid is the factor intellect or openness thus overlapping with other factors that have strong emotional bias.

Block (1995), an ardent opponent of the Big-Five, describes the revisionist history of the development of this approach, with the intention of invalidating its claim as a comprehensive typology of personality. The chronology of its revisionist history is as follows:

- An initial attempt was made to sort through a 400 000 list of terms in order to compile a comprehensive trait description of human difference,
- Allport thereafter compiled a primary list with 4504 terms,
- Cattell backed by a lexical hypothesis and factor analysis reduced this to 35,
- Tupes, Christal and Norman eventually settled on the initial five factors and,
- Goldberg and Costa and McCrae adapted the Big-Five into its current structure.

This chronological set of events, according to Block, highlights the major shortcomings inherent in the Five-Factor model. These include the limitations of using single word descriptors to identify core aspects of personality, the factor analytic approach and its predictions, and the instability of the factors in heterogeneous populations. The five factors of neuroticism, extraversion, conscientiousness, agreeableness, and openness occurr across many cultures and are present even when self-report data was analysed.

4.2.8.2 A descriptive framework of personality

According to McCrae and Costa (1987, 1997) the Big-Five constitute a descriptive paradigm for the study of personality, for it is the best representative of the trait structure of personality. Block (1995), however, argues that these five factors do not constitute a model because of a lack of theoretical and empirical support. Hence, he substituted the use of the term model with that of approach to account for the moderate robustness of the five factors.

Essentially the difference between the descriptive and causal theories relates to the emphasis on phenotype and genotype. In other words, the former attempts to associate mental and physical dimensions to answer the question *why* and the latter confines explanations to the *what* of personality or temperament.

Watson (2000) notes that essentially the biological explanations attached to the PEN model can be applied to four of the dimensions of the Big-Five. The dimensions of neuroticism and extraversion are shared between the two and the combination of conscientiousness and agreeableness can be represented as psychoticism. Another version of the Big-Five model stems from the unification of Eysenck's and Gray's models. Hammond (1994) suggests that the three orthogonal (Eysenck) and the two diagonal (Gray) factors would be a replica of the five-factors if the Cartesian theory of anatomy is used as a basis of biological causation.

There are many researchers, who adhere to the descriptive approach to temperament, and their theories are not borne from neurophsysiologic or neuroanatomic data nor do they rely on this foundation to validate their approach to temperament. Hofstee (1991), as one such adherent, states that the role of personality theorists should be dominated by a descriptive rather than an explanatory discourse. The main argument of Hofstee (1991), driven by his contention that measures of personality and temperament disposition are subjective and judgmental in nature, underscores his hypothesis against biological reductionism. Interestingly, he also discounts the social determinants of personality on this premise. The main thrust of his argument is the determination of bias in temperament measures. Apart from disparity in self and peer ratings there are also different personal views on the social roles. He furnishes the example that parents judge the temperament of their children differently.

Most of the research linking neuro-based functions with dimensions of temperament depends on self-rating measures obtained from inventories and questionnaires. In his view, the only manner to enhance methodological rigour is to use observer ratings because these are replicable, whereas self-ratings are more susceptible to bias without the necessary means of validation. McCrae and Costa (1987) on the other hand, believe that the Big-Five factors provide an adequate framework for understanding individual differences independent of the source of information and the measurement tool. They based their conclusions on results, which showed significant cross-observer agreement on the five factors, using the NEO-PI.

4.2.9 Summary

From the literature it can be ascertained that the composition of temperament varies according to the theoretical model that subserves its construction. Apart from the Big-Five, the composition of Eysenck, Gray, and Strelau derive from the Pavlovian/neo-Pavlovian constructs of arousal and strength of the nervous system. Moreover, the regulative aspect of temperament, in other words its influence on the probabilities of behavioural outcomes derives not from an inherited gene, but rather from the heritable chemical components that regulate synthesis and modulate transmission of neurochemicals.

4.3 Biological bases of temperament

The advocates (Buss, Eysenck, Gray, Zuckerman, etc.) of the biologically based theories rely on the evidence that psychophysiological research has uncovered and supported. These researchers agree that innate biological difference or genotype contributes to temperament variance amongst individuals. Primary support for this comes from twin studies that show heredity to be accountable for almost half of individual variance. In their review of twin studies using the Big-Five factors, Gilliam et al. (2000) found that neuroticism, extraversion, and openness had the highest degree of variance accounted for by genetic influences followed by conscientiousness and agreeableness. Arousal-oriented temperament researchers do not attribute genetic causation directly, but rather infer that the manifestation of phenotypic differences occurs because of the intervening link that drives central nervous system activity. The combination of inherited neurological structure, neurotransmitters, hormonal, and other determinants combine to mediate central nervous system activity (Eysenck, 1991).

Research on biochemical correlates aims to link specific constructs with its biological mechanisms. In some studies a pharmacological agent is applied, changes in the input and output of nervous system reactivity are quantified, and the oscillations in reactivity measured as reflections of different temperaments. An example of this research would be Eysenck's (1970) attempt to make participants more introverted or extroverted in their cortical arousal by administering sedatives or stimulants. Associating a particular trait with its biochemical markers is another method used to establish physiological roots for psychological referents, for example, Zuckerman and Como (1983) measured MAO levels and found that high sensation seekers had lower concentrations of MAO than low sensation-seekers. These studies attempt to unravel how persons with different temperaments adapt to situations, and identify the biochemical correlates of the underlying differences in behavioural and cognitive mechanisms of adaptation.

Individual differences in traits such as impulsiveness, sensation seeking, and novelty behaviour has also been linked to psychobiological mechanisms particularly to the action of neurochemicals. The following discussion will focus on dopaminergic and serotonergic influences on individual differences in temperament.

4.3.1 Neurotransmitters and dimensions of temperament

Many biochemicals play an influential role in determining temperament differences. Researchers have identified catecholamines, acetylcholine, serotonin, cortisol, and opioids as contributing to aspects of temperament such as approach/withdrawal, distractibility, sociability, impulsivity, sensation seeking, strength of excitation and inhibition, etc. (Buss & Plomin, 1984; Cloninger, 1986; Strelau, 1983; Zuckerman, 1987b).

4.3.1.1 Dopamine

Sensation seeking, novelty seeking, extraversion, activity, and rigidity have been linked to dopamine and the dopaminergic system (Cloninger, 1987; Ebstein, et al., 1996; Watson, 2000; Zuckerman, 1983). Dopamine is also indirectly associated with the traits of flexibility and adaptability (Netter, 1991). Parkinson's patients, for example, have depleted dopamine in the basal ganglia and this manifests as a limited ability for altering their cognitive strategy according to alternate stimuli. Moreover, these patients also display negative affect, low activity, and limited interest and interaction with the environment. The symptomatology is consistent with the function of the ascending dopamine systems (mesocortical and mesolimbic), which innervate the frontal and temporal cortex and the limbic structures of the basal forebrain. Approach-related actions and pleasure seeking behaviours are two psychological activities mediated by these systems (Kandel, 2000).

Depue, Luciana, Arbisi, Collins, and Leon (1994) elucidate the role of the dopamine system and its association with positive affect. They administered dopamine agonists to normal adults and measured the intensity of the system's response. Consistent with their predictions, Depue et al. (1994) found a significant correlation between dopamine activity and interindividual differences in positive affective traits. They hypothesise that much of the variance in positive affect amongst individuals could be related to the concentration of dopamine cells in specific areas of the brain and certain individuals may inherit greater concentrations of “joy juice” than others (Meehl, cited in Watson, 2000, p. 226). Researchers, who identify a single gene as the causative agent for the manifestation of specific traits confirm this link between genotype and phenotype (Benjamin, Patterson, Greenberg, Murphy, & Hamer, 1996; Ebstein et al., 1996).

Novelty seeking behaviour entails actions characterised by exhilaration in response to new stimuli. According to Gilliam et al. (2000), about 40% of novelty seeking behaviours are heritable and are linked to dopamine receptors. A significant percentage (10%) of the genetic component is traceable to a mutation on the gene that encodes the D4 receptor (Benjamin et al., 1996). Dopamine has five different receptors identified in various areas of the brain. The D4 receptors are located in the hypothalamus and limbic areas and play a role in emotional functions. The mutation on this gene alters the signalling properties of the receptor in response to dopamine and this sensitivity threshold is believed to be the genetic correlate of novelty seeking behaviour.

Ebstein et al. (1996) also establish a significant association between novelty seeking and a mutation on the D4 dopamine receptor gene. However, they also found that traits such as harm avoidance and reward dependence failed to show a significant link with this mutation, thus strengthening the observed correlation between a genetic polymorphism on D4 and a temperament trait. However, in a recent twin study, the genetic base of novelty seeking is only partially supported, and the trait of harm avoidance also showed additive genetic links (Ando et al., 2002). In addition to novelty seeking trait, Benjamin et al. (1996) in their study found correlations between the mutations on D4 and traits of extraversion such as warmth, excitement seeking, and positive affect, as well as the deliberation facet of the conscientiousness scale.

The dopamine system in the nucleus accumbens is thought to underlie some of these predispositions. This system make up the mesolimbic area, which has a role in reinforcement and reward-dependent learning (Kupfermann, Kandel, & Iversen, 2000). Thus, temperament appears to be reflected in the reward-motivational activities of individuals and certain persons have low dopaminergic tonic activity and are more susceptible to drugs and pleasure seeking activities that impact on dopamine systems (Zuckerman, 1991). However, empirical evidence suggests that noradrenaline and the enzyme dopamine-ß-hydroxylase (converts dopamine to noradrenaline) are negatively correlated with pleasure seeking behaviour, and dopamine is associated with this behaviour because the low conversion into noradrenaline suggests more dopamine in the central nervous system (Schwartz, 2000; Zuckerman, 1991).

According to Strelau and Zawadzki (1995), temporal traits are explained by recourse to tempo of reaction, termination, course of the neural process, and interaction between these neural activities. Due to the actions of dopamine in different parts of the brain, Netter (1991) suggests that it might be involved in temporal processes. The arousal-orienting mechanisms appear to be involved with the energetic aspects of behaviour. Moreover, together with dopamine acetylcholine is believed to mediate cognitive styles (reflexivity, selectivity of attention, distractibility) that are reflections of temperament (Netter, 1991).

Strelau and Zawadzki (1995) hypothesise that in general the production and release of neurotransmitters, the sensitivity of their postsynaptic receptors, and the reactivity of nerve cells to divergent stimuli may explain the energetic traits. More specifically, the traits of sensory sensitivity, endurance, and activity appear to be related to processes of the cortical-reticular system, and emotional reactivity appears to be mediated by the actions of the limbic system and the ANS. Thus, Strelau, Eysenck, and Zuckerman are in agreement regarding the biological underpinnings and the dopamine correlates of action-oriented traits and emotion-oriented traits.

4.3.1.2 Serotonin

Serotonin activity is identified as one of the biological markers determining the threshold for violence and it has been linked to temperament traits such as impulsivity and aggression that are contained in the psychoticism dimension, and to harm avoidance (Cloninger, 1986; Eysenck, 1970). Individuals with low levels of serotonin tend to display more disinhibition, which is a facet of psychoticism, and anxiety and depression, which are facets of neuroticism (Zuckerman, 1991). Eysenck (1992) found that low MAO (enzyme that degrades serotonin) concentrations increase a person's vulnerability to aggressive and impulsive behaviour, and Zuckerman (1987b) found that high scores on the Sensation Seeking scale were inversely correlated with MAO levels.

The results of Eysenck (1992) and Zuckerman (1987b, 1991) provide a glimpse of the atypical role of serotonin on behaviour. Gilliam et al. (2000) relate the story of a Dutch family to demonstrate the complex relationship between serotonin and impulsive behaviour. Fourteen members of the family had a history of impulsive and aggressive behaviour. Each of these individuals had the polymorphism on the gene that encodes for the enzyme MAO A. This genetic defect leads to increased serotonin levels, yet the individuals showed heightened impulsive tendencies. This suggests that both increased and decreased levels can contribute to specific traits, and due to MAO's involvement with other monoamines the interplay between neurotransmitter balances might also contribute to the behaviour. The action of serotonin on various receptors is of particular importance because it provides clues for understanding how the phenotypic and genotypic factors interact.

4.3.1.3 Summary

The validity of results associating biochemicals to specific traits must be evaluated against the following salient point: determining causal and linear relationships between a specific stimulus and a specific biochemical and between the latter and a behavioural output is not possible. Therefore, the link between a neurotransmitter and dimension of temperament is most likely probable and not definite. This scenario is complicated by the fact that a neurotransmitter could be mediating various behaviours depending on the location of release in the brain. Moreover, a measurement of neurotransmitter levels is conducted indirectly via plasma and urine concentrations and these represent only 5% of the brain levels (Netter, 1991).

Utilising the premise that temperament impacts on behavioural probabilities, many studies are conducted on people who have psychopathologic profiles. An extension of this, are studies that aim to provide a link between certain pathological behaviours and temperament in the presence of traditionally classified brain diseases. In Alzheimer's disease, the noncognitive symptoms are characterised by relative heterogeneity across sufferers and one of the vulnerability factors for occurrence of certain symptoms is hypothesised to be temperament.

4.4 Symptom profiles and premorbid temperament - A case for neurological patient groups.

People with certain psychiatric disorders are often presumed to share vulnerability for pathological behaviours, and one of the attributable factors for increased vulnerability is considered to be personality or temperament traits (Andrews, 1996; Boyce, Parker, Barnett, Cooney, & Smith, 1991). There is a wide spectrum of neuropsychiatric and neurobehavioural features that accompany Alzheimer's disease. Explaining all these symptoms by recourse to causative neurological impairment cannot account for the variance observed in the neuropsychological profiles of patients. Hence, drawing from general research on relationships between personality and psychopathology, premorbid temperament assumed the role of a risk agent responsible for the gamut of noncognitive symptoms in Alzheimer's disease.

4.4.1 Predisposition for specific symptoms

Several studies address the issue of temperament as a predisposition factor for noncognitive pathology in Alzheimer' disease, but evidence that unequivocally demonstrates this correlation is modest.

Utilising regression analysis on data obtained from Alzheimer's disease caregivers, Chatterjee et al. (1992) found that premorbid neuroticism precede the occurrence of depressive symptoms in Alzheimer's disease patients, and patient's with delusions are more likely to be perceived as hostile, less agreeable, and emotional (negative) premorbidly. Meins et al. (1998) also demonstrate an association between depression and premorbid temperament characteristics. Alzheimer's patients, who displayed a low threshold for frustration tolerance premorbidly, appear to manifest with more depressive symptoms than those patients who have a greater propensity for toleration. Moreover, they showed a positive association between premorbid extraversion and depression.

In both these studies a single informant was used to obtain information about the patients' premorbid temperament and current symptoms. Expanding on the single informant design, Strauss et al. (1997) found that when using two caregiver sources, the relationship between depression and premorbid neuroticism was insignificant. In other words, when the same informant assessed the personality and current symptoms there was a relationship between neuroticism and depression. The only relationship that was significant irrespective of informant source was between anxiety and premorbid neuroticism. They conclude that retrospective bias may cloud caregiver judgement on some current and premorbid behaviours.

Kolanowski, Strand, and Whall, (1997) obtained information about premorbid temperament from a primary caregiver and information about current behaviour from nursing staff most familiar with the patient in order to control for retrospective bias. Current symptoms of aggressive behaviour are positively related to neuroticism and extraversion and inversely related to agreeableness as measured on the NEO-PI. Conversely, Swearer et al., (1996) found no association between aggressive symptoms and premorbid temperament amongst their sample of demented patients.

A possible explanation for the diverse results could be the use of different temperament inventories. In the latter study, the investigators used the Adult Personality Rating Assessment Schedule, which was constructed for use with mentally impaired elderly patient and may not be a reliable measure of premorbid temperament among demented patients. Other reports of associations between premorbid temperament and noncognitive symptoms in dementia include relationships between premorbid hostility and introversion with delusions, and premorbid openness with hallucinations (Rao & Lyketsos, 1998). Low, Brodaty, and Draper (2002) reported contradictory findings, with associations between higher neuroticism and delusions, higher agreeableness with hallucinations, aggression, and affective symptoms, and higher openness with affective disturbances.

Several other studies have found that specific premorbid behaviours may influence the manifestation of that trait or behaviour during the dementing process. Hamel, Pushkar-Gold, and Andres (1990) and Ryden (1988) observed an association between premorbid aggression and its occurrence in dementia. Analogous research, however, found no significant association between premorbid aggressive traits and aggressive symptoms in dementia (Burns, Folstein, Brandt, & Folstein, 1990; Swearer et al., 1996).

The challenges faced in assessing premorbid temperament include retrospective bias that may contaminate recollections and the difficulty in determining when the disease began in order to distinguish between premorbid disposition and disease disposition. Some of the studies reviewed above have addressed the former challenge by including secondary informants or using a clinician or nurse to rate current behaviours. The main limitation of these studies, however, is the small sample sizes used and the cross-sectional correlational designs that do not address causal relationships.

Meins and Dammast (2000) and Strauss et al. (1997) contend that a relationship does exist between premorbid temperament and specific noncognitive symptoms in Alzheimer's disease, and that this is not a derivative of retrospective bias but rather a premorbid diathesis for neuropsychiatric and neurobehavioural symptoms. The mechanisms underlying this relationship will be elaborated on in the following section.

4.4.2 Pathoplasticity, predisposition, and self-fragmentation

Berrios (1989) considers the pathoplastic nature of personality as a possible reason for the changes observed during a dementing process. For example, he reflects on two change-mechanisms: a mechanism of release caused by the disease and a mechanism of magnification of personality traits. Berrios (1989) believes that in both instances one is likely to observe an exaggeration of the premorbid temperament profile that renders a caricature of a prior self. An exaggeration of premorbid personality was the conclusion that O'Connor (1987) reached to explain the presence of behavioural disturbances in 43% of his sample, and the interpretation of this finding rests on the theory of frontal lobe disinhibition in dementia. However, the idea of a dementing illness causing an exaggeration of personality by whatever means, partially explains the quantitative (energetic, happy) and not the qualitative behavioural displays (delusions and hallucinations) accompanying the disease.

Widiger and Trull (1992) state that there are various forms of the relationship between premorbid temperament and noncognitive symptoms, but separating them is not possible. Thus, the relationship between predisposition and occurrence stems from either a pathoplastic effect or comorbidity of pathoplasty and disease process (predisposition). Several studies have found, however, that persons with dementia retain some of their unique traits despite the disease (Kolanowski et al., 1997; Welleford, Harkins, & Taylor, 1995).

Supporting the argument against the pathoplastic effect of personality on noncognitive symptoms, Welleford et al. (1995) found that the changes observed after the disease onset, are characterised by a stereotypic change, where patients show similar increases and decreases in certain characteristics while retaining individual variability. For example, several researchers utilising the NEO-PI on dementia patients found a general profile of change, with increases in neuroticism and decreases in extraversion, openness, and conscientiousness from premorbid levels to current levels (Glosser, Clark, Freundlich, Kilner-Krenzel, Flaherty, & Stern, 1995; Kolanowski et al., 1997; Welleford et al., 1995).

The stereotypic changes seemed to occur irrespective of a patient's premorbid temperament, and previous personality traits were not exaggerated during the disease. These results suggest that predisposition is the strong contender as an influential agent for noncognitive behaviours. This contention is enhanced by results showing that neurological patient groups (Alzheimer's and Parkinson's disease) usually exhibit similar changes in personality after onset of disease. Glosser et al. (1995) state that the changes in personality may reflect an individual's attempt at adapting to the accompanying symptomatology. It is the predisposition that determines whether this adaptation or pathoplasticity manifests as pathological behaviour.

A word of caution against the interpretability of the studies pertains to the use of the same personality inventory, small sample sizes (n= 29-40), moderately affected patients, and a single informant design that does not address the influence of retrospective bias. A moderately affected group may show specific patterns of change based on the duration of disease course. In other words, these patients are still adapting to the loss of abilities and functions and their adaptive response may be different from a group who are mildly affected or severely affected by the disease. Longitudinal studies are needed to ascertain the 'stability' of stereotypic changes and their relationship to premorbid temperament.

A related view on the association between premorbid temperament and noncognitive disturbances, declares that the self is a “phenomenological agency that co-ordinates the demands of the immediate situation with the constraints imposed on the individual by dispositions and residues of life experiences (Graziano, Jensen-Campbell, & Finch, 1997, p. 393). In other words, the phenomenological self acts as a mediator that converts disposition to situational adaptation.

In Alzheimer's disease, the essence of the self erodes and the dissolution can create, according to this view, a perturbation in the mediatory processes between self and situation. Lazarus et al., (1996) agree that certain noncognitive symptoms may arise because of the disturbed interaction between personality, self, and situation. However, they contend that a hallucinatory symptom could be an adaptive compensatory mechanism of the dementing patient. Hallucinations relating to deceased parents or kin may relieve the feelings of self-fragmentation, with premorbid dispositions likely to influence the occurrence of noncognitive symptoms in these situations.

4.4.3 Summary

Temperament as the constitutional aspect of personality is a known factor in the genesis of neurobehavioural and neuropsychiatric disorders, particularly anxiety and depression (Andrews, 1996). The comorbidity of a vulnerability factor and a disease process appear to interact and enhance individual liability for the occurrence of noncognitive signs and symptoms. The research to date is supportive of the predisposition hypothesis but is not conclusive. Methodologically, studies of cognitively impaired individuals are dependent on informant reports, utilise different tools, and varied definitions of premorbid time frames.

Such conflicting designs and descriptions underlie the limited research endeavours in this area.

4.5 Conclusion

The relationship between neurotransmitters and temperament disposition appears to be mediated through the variable effects of genetics on production, release, and reuptake in the central nervous system. The brain structures and their activation thresholds are also involved in the biological substrates of temperament and mediate the general heritable predisposition rather than the specific symptoms.

There is little doubt that temperament is a reflection of underlying brain functions such as the workings of distinct neural subsystems and their biochemical and regulatory levels and patterning. The discord concerns issues about the nature and specificity of the representation. Similarly, a growing body of research attests to the significance of a relationship between predisposition and noncognitive symptoms of Alzheimer's disease, but the discord pertains to the nature and specificity of this relationship.