CHAPTER 1: INTRODUCTION

Leg Shaking is a movement stereotypy. According to Jankovic (1999), stereotypy is defined as an involuntary or unvoluntary, coordinated, patterned, repetitive rhythmic, purposeless but seemingly purposeful movement. This thesis attempts to study the phenomenology of leg-shaking and its possible clinical significance.

The broad research questions that are addressed are as follows:

1. What is the frequency of the occurrence of leg-shakers in a population? Is it influenced by environmental settings?
2. Is leg-shaking linked to certain personality and attention features?
3. Does leg-shaking have a genetic basis?
4. Is leg-shaking linked to Cortisol?

This chapter is an introduction to concepts that are relevant to this study of leg-shaking as a movement stereotypy.

1.1 Rationale of study

The aim of this thesis is to study the phenomenon of leg-shaking observed in some individuals. This motor behavior comes under the category of purposeless but seemingly purposeful stereotypic movement (Jankovic, 1999). According to Jankovic, stereotypy is defined as an involuntary or unvoluntary, coordinated patterned, repetitive rhythmic, purposeless but seemingly purposeful movement.
The objective of this investigation is to identify and characterize leg-shaking in terms of description, possible etiology, and links with personality traits.

Stereotypical behavior is common in animals, and more common in farm and zoo animals housed in restraining environments with low stimulation (Dantzer, 1986). With the development of stereotypies, there is a reduction in the broad behavioral repertoire normally displayed by unrestrained animals. Therefore, stereotypy has been viewed as either a self-generating sensory stimulus, or a motor expression of an underlying tension or anxiety. The repetitive and ritualistic behavior displayed by some animals has been used as an experimental model of Obsessive Compulsive Disorder (OCD) (Pitman, 1989).

It is well known that stereotypies often accompany a variety of behavioral disorders such as anxiety and OCD (Zohar & Insel, 1987; Rogers & Hymas, 1988), Tourette’s syndrome (Jankovic & Rohaidy, 1987), schizophrenia (Jager, 2000; Forehand & Baumeister, 1971), mental retardation and autism (Dura, et al, 1987) and akathisia (Stacy, et al, 1993).

Repetitive and patterned movements phenomenologically identical to stereotypy are characteristically seen in patients with tardive dyskinesia (Stacy, et al, 1993). More complex stereotypies, such as hair and face-rubbing, picking at clothes, crossing and uncrossing of legs, adduction-abduction, up and down pumping of legs, arising and sitting down, marching in place, pacing and shifting
weight, is often associated with feelings of restlessness, and are typically seen in patients with tardive akathisia (Burke, et al, 1989). Akathisia may be caused by neuroleptics, Parkinson’s disease or other causes and is sometimes confused with the syndrome of restless legs (Blin, et al., 1990; Lang, 1993). Both disorders exhibit stereotypical movements and motor restlessness.

It is obvious that neuropathological features represent anatomical substrates of functional abnormality. Specific circuits of basal ganglia may underlie aspects of movement disorders and psychological symptoms. Leg-shaking is a movement stereotypy, just as a postulated relationship exists in movement disorders and psychopathology, a link between leg-shaking and certain personality traits and cognitive features may also prevail.

Neuro-motor abnormalities have been found to predate the onset of schizophrenia by many years (Fish, et al, 1992; Walker, et al, 1993,97,99). Walker (1994) found that abnormal hand postures and choreo-athetoid movements of the upper limbs were observed with greater frequency in pre-schizophrenic children than in their healthy siblings.

Since schizophrenia was first conceptualized, neuro-motor abnormalities have been part of its clinical picture. Manschreck and Ames in 1986, categorized motor abnormalities according to hypokinesia (decreased motor activity) and hyperkinesia (increased motor activity). Numerous researchers have found motor disturbances in non-medicated (neuroleptically-naïve) patients (Caliguirri, Lohr, &
Jeste, 1993; Chatterjee, et al, 1995; Flashman, Flan, Gupta & Andreasen, 1996; Gupta, et al, 1995; Buchanan, et al, 1990; Khot & Wyatt, 1991; Manschreck & Ames, 1986; Owens, et al, 1982; Schroeder, et al, 1992; Torrey, 1980.). All of the above findings confirm that spontaneous dyskinesia is central to the spectrum of several psychological disorders. So, surely, leg-shaking which is an unusual motor behavior must have a reason. Leg-shaking could be a marker for some specific psychological features lying in the twilight zone between normality and pathology and hence, this study.

1.2 Kinesiology

Kinesiology is a study of body movement. This study may be conducted from four viewpoints.

1. Anatomical, describes the structure of the body and its parts, and their potential for movement.

2. Physiological, studies processes involved in the sensations, perceptions and motivation that stimulate movement and the neurological controls.

3. Mechanical, considers the force, time and distance relationships in body movement.

4. Sociocultural, is the meaning and interpretation given to various movements in different human settings (Higgins, 1977).
1.2.1 *The musculoskeletal basis for movement.*

The framework of the body consists of bones articulating at the joints. It is at the joints that motion takes place. The bones form a hard core of the various body segments, which move around the joints. Soft tissue structures such as muscles, connective tissue, blood vessels, nerves and skin complete the mass of each segment.

Joint motion may be caused by an internal muscle contraction, or due to gravity, manual, or mechanical force. A joint is a junction between two bones. They may be classified as being synovial or freely movable, cartilaginous or slightly movable, and fibrous or fixed.

Synovial joints are of most interest in human studies. Joints unite the various body segments. A body link is the distance between joint axes. A link unites joint axis. When a number of links are united in series, they form what is called a kinematics or a joint chain. A kinematic chain is a combination of several successively arranged joints constituting a complex motor system.

The body is a series of long and short bones connected at junctions or joints. For movement to occur, the junction must allow for free movement in the directions that their design permits.

1.2.2 *Neural Control Of Human Movement*

The control of movement has traditionally been considered to be hierarchical with the highest, being the cortical level of control organizing voluntary skilled movement. However, in reality there is no separation between voluntary movements and the background of
postural control that maintains the body in an upright position with the aid of automatic reflexes and responses. Therefore, parallel systems of control with integration of all levels, rather than just a serial hierarchy may be a more appropriate description (Kidd, et al, 1992).

The grey matter of the spinal cord is the seat of reflexes and other automatic movements. The spinal cord segments are made up of millions of sensory, motor, and interneurons. It also has a specific interneuron called the Renshaw cell.

Muscle spindles detect rate and changes in length, whereas Golgi tendon organs detect degree and rate of change of tension. Signals from the sensory receptors operate at almost a subconscious level, transmitting information to the spinal cord, cerebellum, and cerebral cortex where they assist in the control of muscle contraction.

Overall the motor related functions of the brain stem are to support the body against gravity, generate gross stereotyped movements of the body and maintain equilibrium. Therefore, it is predominantly concerned with the control of axial and proximal limb muscles.

The basal ganglia comprises of structures such as the caudate nucleus and lentiform which serve as side loops for feedback of information between the cerebral cortex and thalamus above and the brain stem and spinal cord below. This region is involved in the modulation of all types of movement by feedback control (Guyton, 1991).
It is believed that the basal ganglia play an essential role in the initiation of most activities of the body in association with the sensory cortices. Information is then returned to the motor cortex for refinement. This negative feedback loop provides the inhibition of unwanted movements, which allow the fine control, or regulation of gross intentional movements that are normally performed subconsciously. Working in association with the brain stem region, the globus pallidus operates as a motor relay station. It helps to control the axial and hip girdle movements so providing the background attitudinal movements and stability to the body and proximal parts of the limbs.

The motor cortex is the main center for the control of voluntary movement. Its primary function is in the planning and execution of many complex movements. It occupies the posterior half of the frontal lobes. It is closely related to other motor areas including the primary motor area, pre motor and motor association area.

The cerebellum monitors and makes corrective adjustments in the motor activities elicited by the other parts of the brain. Extensive input and output systems operate to and from the cerebellum. The cerebellum does not initiate motor activities but plays a role in planning, mediating, correcting, coordinating and predicting motor activities especially for rapid movements. Working with the basal ganglia and thalamus the intermediate zones of the cerebellum help to control voluntary movements by utilizing feedback circuits from the periphery of the brain. This provides smooth coordinated movements of
agonist and antagonist muscle groups allowing the performance of accurate purposeful and intricate movements.

Voluntary movements despite their name, are not purely voluntary, but are also controlled at a subconscious level. Likewise ballistic movements need the excitation from the cerebellum to get the speed of the movements, and then inhibition to stop the movements. Planning the sequence of movement is necessary for a smooth and orderly transition of one movement to the next. The cerebellum also serves as an error-correcting device for goal directed movements therefore, it is important in the process of learning and acquisition of motor skills.

1.2.3 Central pattern generators

The innate capacity for the generation of rhythmic movement patterns is found throughout the animal kingdom. Breathing, chewing, and locomotion are examples of rhythmic motor patterns seen in vertebrate and invertebrate species. These motor patterns are produced in large part by the activity of collections of neurons whose membrane potentials oscillate rhythmically and are found in the spinal cord. These neurons are collectively termed central pattern generators (CPG). Humans produce rhythmic motor patterns during all forms of loco-motor activity, whether the task is walking, running, cycling, crawling, creeping, or swimming.

Human movement disorders, and all forms of rhythmic human movement, share a similar neural control, which can be thought of as a
common core composed of oscillatory neurons that drive the basic motor pattern (e.g., locomotor CPG). As described above, a CPG for locomotion consists of interneurons that generate the pattern or locomotor drive to motor neurons, thus yielding rhythmic movement. The interneurons that comprise the CPG are those involved in the timing and oscillatory behavior (i.e., the "rhythm" in rhythmic movement).

1.3 Nosology of movement disorders in psychiatric illness

The DSM-IV (1994) and DSM-IVR(2000-text revision) provide the nosology for movement disorders associated with psychiatric illness. The four major movement disorders are Akathisia, Parkinsonism, Dystonia, and Tardive dyskinesia. In contemporary literature there are numerous accounts of the presence of abnormal motor movements in chronic psychiatric populations. Marsden, Tarsy, and Baldesarini in 1975, in a review of motor dysfunctions, provided an extensive listing of abnormal movements evident in this population. They suggested, for example, that psychotic patients might display the following motor abnormalities: repetitive blinking, facial twitching, tongue protrusion, hand-kneading, leg rubbing, shoulder-shrugging and / or excessive leg-lifting. Other authors (Granacher, 1981; Yung, 1983) have also taken note of the aforementioned symptoms and expanded to include writhing movements of the trunk, incessant pacing and violent arm swinging. Some authors (Flinn & Bazzell, 1983; Lakke, 1981,) have also described many individual motor abnormalities.
Akathisia is marked by a state of motor restlessness or an inability to tolerate inactivity. There is a subjective feeling of tension, a desire to be in motion, and a sense of pulling on in their lower extremities (Tarsy, 1984). A subtype of Akathisia that has received the greatest amount of attention in literature and poses the greatest difficulty regarding the class of movement disorders is "pseudo akathisia". This is defined as overt motor manifestations of restlessness (e.g. pacing) without accompanying features of subjective unease or tension. This dyskinesia usually manifests behaviorally as a constant shuffling or tapping of feet, a constant shifting of weight, rocking of the trunk while standing and incessant running or pacing (Flinn & Bazzell, 1983).

The parkinsonian syndrome associated with chronic psychiatric symptoms, shows initial signs of reduction of facial and arm movements, moving on to a generalized or lowering of all volitional movements (Freedman, 1973). Slow movement rigidity and limp tremors are also seen.

Dystonia involves bizarre muscular spasms affecting head and neck muscles (Freedman, 1973). There may also be involuntary spasms of the tongue and mouth and facial grimacing. Additionally, these muscular contractions may produce postural abnormalities and/or differences in moving (Yung, 1983).

Tardive dyskinesias are also referred as Bucculinguomasticatory syndrome. It is typified by protruding, twisting and curling tongue movements, bulging of cheeks and various chewing movements.
(Freedman, 1973). This syndrome develops in some patients during long-term treatment with neuroleptics. Spontaneous dyskinesias are movements, phenomenologically similar to the above and were very early described by Emil Kraepelin (1913) in patients with schizophrenia long before the introduction of neuroleptics.

There is a vast array of abnormal motor behaviors including slowed movement, shuffling gait, collapsed posture, low voice volume, monotone speech, lack of facial expression, stereotyped movements, repetitive behaviors, and purposeless movements of the limbs and trunk. These were recognized as fundamental features of mental illness by the earliest psychiatric writers, including Aretaeus of Cappadocca, Hippocrates, Caelius. Aurelianus and Plutarch (Zilbourg, 1944).

Movement disorders are also known to develop in the context of streptococcal infection. These disorders are autoimmune and are mediated by antibodies that bind and cause dysfunction within the CNS, and the basal ganglia, an example being Sydenham's chorea (Dale & Heyman, 2002).

Body focused repetitive behaviour (BFRB) such as skin picking, scratching or nail biting is associated with more somatic activity. These behaviors though physically and socially detrimental have received limited attention (Teng, et al, 2002).

Motor behaviors that reflect characteristic stereotyped behaviors are seen in Fronto Temporal Lobar Degeneration (FTLD). This is a common form of cortical dementia (Manschreck & Ames, 1986).
There is also a miscellaneous and formally unclassified phenomenon of odd and unusual movement disorders. They have now been largely recognized to be symptoms of neurological and systemic disorders (Lees, 2002). These disorders are a) oculo masticatory myorhythmia, which is diagnostic of Whipple’s disease. b) Bizarre nocturnal movements including dystonia stereotypies, chorea and even vocalizations that are increasingly, recognized as a presentation of medial frontal seizures. c) Ekbom’s syndrome has become de rigueur as a subject of consequence following dopamine receptor agonist activity. d) The Huntington’s mutation has been found in middle-aged patients presenting with Parkinson’s syndrome and generalized myclonous cases. f) Chorea-Acanthocytosis may present with Parkinsonism. g) Spinocerebellar ataxias are accompanied with dystonia or chorea h) Wilson’s disease can present with stereotypies l) Freidireich’s Ataxia occasionally presents with myoclonus or chorea j) Spasmodic Torticollis, musician’s tremors, Propriospinal myoclonus, startle disease and tics have now an acceptance in neurology.

1.4 Stereotypy

Luescher (1998) defines a stereotypy as a regular repetition of a small number of identical acts, or group of acts, without a spontaneous stop, and without any regulation. He proposes that several stereotypies are evolving from displacement activities, losing their regulation and becoming stereotyped with time. Overall (1998) defines a stereotypy as
“a repetitious, relatively unvaried sequence of movements that have no obvious purpose or function, but that are usually derived from contextually normal maintenance behaviors e.g., grooming, eating, walking.” She differentiates stereotypies and obsessive-compulsive behaviors, saying that OCD includes stereotypies, self-directed behaviors, and so forth. She further defines stereotypies and compulsive behaviors as "virtually synonymous"; they are "mindless, repetitive actions", derived from "species-typical naturalistic survival-oriented behaviors" (like predation, ingestion, locomotion and procreative activities). Several of these actions may lead to "self-injurious behavior" (SIB). "Compulsive behaviors stem from innate behaviors that have become displaced and autonomous, persisting as fixed motor sequences".

These definitions may seem confusing, sometimes even paradoxical. A stereotypy may describe a sequence of act, a symptom, even a disorder. In ethology, fixed action patterns and ritualized behaviors may be stereotyped, because they are repetitive, and performed in constant form. But they have a purpose and are functional.

Stereotypies do not include tics that are sudden, rapid, recurrent, nonrhythmic, single muscular movements such as face twitching, tongue dragging, lips licking, or vocalization.

In this definition, a stereotypy is a symptom; it is not a diagnosis. Stereotypies may accompany several clinical behavioral syndromes, such as overactivity disorder, anxiety, dysthymia (unipolar
or bipolar disorder), and dissociative disorders. Stereotypies may also be present in neurological disorders, such as Fronto-temporal neurodegeneration (Pick's dementia and / or non-Alzheimer's non-Pick's dementia in people).

Clinically, stereotyped behaviors are seen in conjunction with a variety of psychiatric, neurological, and developmental disorders such as Schizophrenia, Tourette's syndrome, Rett's syndrome, mental retardation and autism. Up to two thirds of individuals with mental retardation exhibiting stereotypic behaviour. (Baumeister & Forehand, 1973). Furthermore, stereotyped movement is one defining feature of autism. Stereotyped behaviour in humans often consists of head rolling, head slapping, and body rocking. Stereotypies also vary in frequency, intensity and topography among individuals. Also prevalent and frequently co occurring with stereotypy are compulsions (Bodfish, et al, 1995)

Stereotypic movement disorder (SMD) was previously termed stereotypy/habit disorders. It is characterized in DSM-IV by repetitive, non-driven, and non-functional motor behaviour, markedly interfering with normal activities and could result in self-injury requiring medical treatment. It differs from DSM-III stereotypy habits in that, the diagnosis is seen as more independent of its commonly associated diagnosis of mental retardation or pervasive development disorder. While stereotypic movements can also be an integral part of disorders of the repetitive behaviors such as OCD and tics, they are also found in individuals who undergo severe deprivation (Bartlet & Lim silica, 1992).
Motor rhythms have been defined by Foster (1998) as head rolling, body rocking, head banging, thumb and finger sucking, foot tapping, lip biting, toe and hand sucking and teeth grinding. Infants develop body image through cutaneous, visual and kinesthetic sensory inputs. They are intimately associated with maturation and development of motor skills in infants. (Mittelman, 1954).

For the purposes of this review, and the investigation, stereotypy is described as an involuntary or unvoluntary, coordinated, patterned repetitive rhythmic purposeless, but seemingly purposeful or ritualistic movement, posture or utterance (Jankovic, 1999). In the context of this definition it is important to first clarify the terms voluntary, involuntary or unvoluntary, and automatic movement. Voluntary movements are either intentional (planned, willed, self-initiated) or responsive (occurring in response to an external auditory, visual or tactile stimulus). Studies showing a delay in the execution of voluntary movements by electrical or magnetic brain stimulation suggest that the motor programmes for the initial sequence of agonist antagonist activity required for voluntary movement are stored outside the motor cortex but that coded instructions are released to the motor cortex immediately prior to the execution of the movement. Involuntary movements can be subdivided into non-suppressible e.g. most hyperkinetic movement disorders particularly tic and some tremors dystonias choreas and stereotypy.

Stereotypical movements could be classified as either simple (foot-tapping, body-rocking) or complex (complicated rituals, sitting
down and rising from chair). Stereotypies can also be described according to distribution of the predominant site of involvement (orolingual, hand, leg, and truncal). The term stereotypy should be used to describe a phenomenological, and not an etiological category. Certain stereotypies such as tapping of the feet, adduction-abduction and crossing and uncrossing of legs may be part of the repertoire of normal individuals (Jankovic, 1999).

Psychomotor agitation is commonly associated with psychiatric disorders. A systematic Medline search of terms-psychomotor, agitation and restlessness showed the motor manifestation was described as restlessness, to the extent of being stereotypic aimless, non-purposeful, non productive and goalless. Descriptions of stereotypies include behaviors such as nail-biting, foot-tapping, hand-wringing, fidgeting with hair skin clothes or other objects (APA, 1994).

The term restlessness has been variously and imprecisely, applied in the clinical situation, and also used to describe some aspects of normal behaviour (Kruk & Sachdev, 1996). A nervous habit is a loosely defined term, popularly applied to terms like jitteriness, fidgetiness and restlessness. They also refer to apparently irrelevant self or object manipulability, and common discrete non-verbal actions produced by people in everyday life settings (Yung, 1983).
1.4.1 Neurochemical basis of stereotypy

From the neurochemical, neuroanatomical, and neurofunctional vantage points, Stereotyped Motor Disorders (SMD) and stereotypic behaviors are quite heterogeneous and rather poorly understood. Several neurochemical systems appear to play a role in the mediation of stereotypic movements with or without Self-injurious behaviour (SIB). Due to the mutual interactions among many of the brain's neurochemical pathways, it is a challenging proposition to determine what neurochemical or neuroanatomic alteration is primary with regards to a behavior or disorder. This further heightens the importance of distinguishing among SMDs and making a further distinction between SMDs and stereotypic behaviors that may or may not be part of SMD per se.

The dopaminergic, serotonergic, endogenous opiate, and noradrenergic pathways are some of the better studied neurotransmitters in this area. Alterations in all of these have been associated with various SMDs and stereotypic behaviors. However, the biological mechanism underlying these disorders and behaviors remain unclear. Alterations in amount of neurotransmitter, receptor number, or affinity, and response to a specific pharmacological agents may not be primary, but rather compensatory changes (Grossman & Verodyev, 1998).

Further, the role of second messenger systems in the pathophysiologic mechanisms of psychiatric disorders is poorly understood. Further investigation of these underlying pathways may
ultimately clarify how seemingly divergent biological findings and efficacious pharmacological treatments may be related by a more basic mechanism. From a functional perspective, there are suggestions that the prefrontal-basal ganglia-thalamic circuits, along with cerebellar involvement, may be implicated in SMDs and stereotypic behaviors. Although various animal models of SIB and stereotypic movements exist, further work to elucidate the relevant neurobiology for humans is necessary.

1.4.2 Leg-Shaking:

The behaviour under study in this thesis is leg-shaking. This is a stereotyped behavior. A stereotypy is defined as an involuntary or involuntary, coordinated, patterned, repetitive, rhythmic, and purposeless but seemingly purposeful or ritualistic movement (Jankovic, 1999).

From an operational point of view, leg-shaking is a rhythmic, stereotyped, involuntary, involuntary repetitive movement. This behavior is quite operationally defined by listing the different actions of the movement involved thereby attaching a degree of precision and reliability. Leg-shaking has the simplicity of a response indicator.

Using a molar approach the larger whole behaviour was split into its smaller segments in units of leg-shaking. The following are general descriptive definitions of leg-shaking movements and the ten specific types of leg-shaking behavior were listed which included the total
universe of leg-shaking behavior (refer to Appendix B for list with line diagrams).

A. Flexion in which the angle between the surfaces of two adjacent segments decreases as the joint is bent.

B. Extension, in which the angle between the segments increases. It is the opposite movement to flexion.

C. Dorsiflexion, where the leg is pulled up towards the leg.

D. Plantar flexion, in which the foot moves downward from the leg.

E. Abduction, in which the segment moves away from the middle of the body.

F. Adduction, in which the segment moves towards the midline of the body.

The nerves and muscles involved in the leg-shakes are given in Appendix C.

1.5 Cortisol

Cortisol is an important gluco corticoid secretion in humans. It is the end product of the hypothalamic-pituitary-adrenal (HPA) axis. It is a steroid hormone secreted by the outer cortex of the adrenal gland. Its secretion is stimulated by the adrenocorticotropic (ACTH) hormone, produced by the pituitary in response to the corticotrophin-releasing hormone (CRH). It is a product from neurons in the para ventricular nucleus of the hypothalamus. After its release, the major part of Cortisol binds to the plasma proteins, cortico steroid binding globulin (CBG, or transcortin) and albumin, which prevents the hormone from
penetrating the membranes of their target cells. About 3 to 5 percent of the total Cortisol is the unbound, biologically active fraction. This active fraction has permissive suppressive, stimulatory, and preparatory action effects in the realm of cardiovascular functions, fluid volume and hemorrhage, immunity and inflammation, metabolism, neurobiology, and reproductive physiology (Bartels, et al, 2003).

Cortisol shows marked circadian rhythm with peak levels usually found in the early morning hours and decreasing concentrations there after (Curtis, 1972). It also plays a role in the metabolism of proteins, gluconeogenesis and lipid metabolism. In addition, it supports vascular responsiveness, skeletal turnover, muscle function, immune response and renal function (Berne & Levy, 1997).

Saliva has become popular in recent decades for the measurement of hormone concentration. Saliva can be easily and painlessly obtained from the study participants as these concentrations are static during extended periods without freezing when exposed to widely varying temperatures and movement (Clements & Parker, 1998).

Despite its potential as a marker of adrenocortical status, previous studies have shown that the awakening free cortisol increase is characterized by both inter and intra individual variability. Among the possible contenders, gender, smoking and use of oral contraceptives each account for approximately 1 to 4 percent of the total variants observed. (Wust, et al, 2000). It is also known that emotional states are capable of activating a neuroendocrine cascade involving salivary Cortisol release.
Neuroanatomically, the HPA axis is more extensive than its name implies. Efferent projections terminate throughout the body and brain and promote life activities.

1.6 Human genetics

Research in human genetics currently involves the effort to identify and locate the function of roughly 40,000-80,000 genes that make up the human genome. The 20th century began with the rediscovery of Mendel’s laws of heredity.

DNA is a double helix that includes four different bases. They are Adenine (A), Guanine (G), Thiamine (T), and Cytosine (C). The DNA codes for the synthesis of the 20 amino acids. This is done by means of sequences of three bases, or codons.

The most common patterns of inheritance that result in genetic disorders are Mendelian, (in which a single gene is altered) chromosomal, and multi factorial.

Mendelian conditions are most often inherited in either autosomal dominant, autosomal recessive, or X-linked recessive patterns.

Autosomal dominant disorders are caused by the presence of mutation on only one copy of a gene pair located on an autosome (not a sex chromosome). Men and women have an equal chance of inheriting the abnormal genes and the affected person has a 50% chance of passing on the abnormal gene to each offspring. Pedigrees that
illustrate dominant disorders often appear to have a vertical pattern of transmission with affected persons in every generation.

Autosomal recessive disorders occur if there are mutations on both copies of the gene pair in an autosome. In such a case men and women have an equal chance. When two heterozygotes (carrier parents with one abnormal gene each) reproduce, there are three possible outcomes:

a) 50% chance that a child will inherit one abnormal copy and be a carrier.

b) 25% chance of inheriting, both normal copies of the gene, and being neither affected nor a carrier.

c) 25% chance of inheriting, both abnormal copies, and being affected.

Pedigrees that illustrate recessive conditions often have a horizontal transmission pattern, because there may be family members affected in the same generation.

X-linked recessive disorders such as colour blindness nearly always affects males because the abnormal gene is located on the X chromosome. Female heterozygotes carry the abnormal gene on the X chromosome; they usually don’t have symptoms of the disease because the healthy genes on the other X chromosome compensates for the mutated gene. Women who are carriers have a fifty percent chance of transmitting the gene to their male offspring who would then be affected. They also have a 50% chance of passing the abnormal gene to the female offspring, who would be asymptomatic heterozygotes. Transmission is not possible from man to their male offspring because
the abnormal gene is located on the X chromosome and men transmit only the Y chromosome to their sons (McKusick, 1998).

1.6.1 Genetic variability

Variable expressivities: Since the expressions of many genetic mutations may be influenced by both environment and genetic factors, it is often the case that people who carry the same gene present a range of symptoms.

Incomplete penetrance: This refers to autosomal dominant conditions that, while having a high probability of occurring in other family members (known as high recurrence risk), may also present as new mutations for the first time within a family (Wilson, 2000). At other times a particular disease might skip a generation. This is an extreme case of a low level of expressivity. Some individuals who logically ought to show symptoms because of their genotype do not. In such cases even the most careful clinical evaluation has revealed no symptoms and the person may be misclassified until suddenly he or she transmits the gene to a child who is then affected.

Pedigree analysis, studies the incidence and progression of a disease in a family system. A pedigree is a diagram of a family indicating the structures of relationship between a proband (the clinically affected or at-risk individual through whom attention is first drawn to a family pedigree). Only large completed multigenerational family pedigree analysis would show that a particular behaviour is more likely to have a single underlying genetic basis.
A Mendelian inheritance pattern is seen when a single gene is responsible for the disorder. There are only a few rare alleles that cause problems, and they do so mostly only when the person is homozygous for that allele (McKusick, 1998).

The pedigree approach is essentially a reductionist approach. All valid arguments against a reductionist approach must be kept in mind. Also there are great complexities in actual gene finding and the understanding of the phenotype from the genotype both of which have been portrayed here far more optimistically than the true state of affairs. Pedigree analysis provides documentation for an autosomal dominant disorder with reduced penetrance. Variable expressivity and genetic heterogeneity serve as confounding factors in linkage analysis. (Burton, 2003)

Simple motor behaviors like leg-shaking probably will follow simple Mendelian inheritance patterns.

1.7 Attention

One of the most critical abilities of higher organisms is to deal coherently with the constant stream of sensory information and, parallely, to decide the appropriateness and timings of responses. This ability is generally called attention and was described by William James as “the taking possession by the mind, in clear and vivid form, of one out of what seems several simultaneously possible objects or trains of thought.” (James, 1890) Attention in this framework is a key component of normal consciousness.
In a simplified psychological model, attentional mechanisms can act at either the input or output levels of information processing. At the input level, they enable discriminations between relevant and irrelevant material and set priorities. At the output level, they orchestrate the responses for appropriate motor intention. The ranges of deficits in attentional behaviour evident after focal damage to different brain loci (Heilman, et al, 1987) are in keeping with the hypothesis that attentional mechanisms influence information processing.

Selective attention is required in tasks that involve the inhibition of competing responses. J. Stroop in 1935 devised such a task that was considered a test of prefrontal functions based on its performance with patients with frontal lobe lesions (Perret, 1974).

The physiological effects of physical arousal on the human body are relatively well known, but much less is known of the psychological variables (Tomporowski & Ellis, 1986). A class of psychological variables believed to be affected by physical arousal is exercise and is related to information processing and cognition. A subjective report of its effect on mental activities has been available. Some exercisers report that physical exertion facilitates their thinking processes while others report a debilitating effect.

Early reviews (Gutin, 1972; Weingarten, 1973) of research have examined the effects of physical arousal on cognitive tasks. They drew on two competing theoretical frameworks that, at the time, played major roles as explanatory models of motor performance. The inverted-
U hypothesis first proposed by Yerkes and Dodson (1908) and expanded by Malmo (1959), Duffy (1957), Hebb (1955), and Martens (1974) predicts that the current level of physical arousal will interact with an individual's ability to perform psychomotor tasks. As physical arousal increases, performance is predicted to improve up to an optimal point and to deteriorate with further increases. The drive theory hypothesis (Spence & Spence, 1966) suggests that an increase in physical arousal should facilitate performance in a linear fashion. Drive theory assumes that the strength of a given response is a multiplicative function of the total drive state and habit strength.

More recently, theories of attentional processes have been used to explain how the reception and processing of information influences the execution of cognitive and motor tasks. The contention, that physical arousal influences attentional processes has been accepted as virtually axiomatic by most learning theorists. Landers (1980) have summarized the major theories of arousal and psychomotor performance, and he suggests that the model described by Easterbrooke (1959) provides the prototype for current theories of attention. Easterbrooke's theory proposes that any variation of physical arousal will produce a change in attentional processes. Specifically, an increase in arousal will result in the shift or "narrowing" of attention to those components of a task that are central to correct performance; attention to those components that play a limited role in correct performance will be reduced. As the level of physical arousal increases, the selection of task relevant stimuli may be restricted
because of continued narrowing of attention and, as a result, performance will deteriorate. This model provides a framework for more recent theories like the central hypothesis of the general theory of Kahneman (1973). It states that each individual has a fixed amount of attentional capacity that can be allocated to the process of incoming information. Some forms of information processing such as memory for spatial locations, time and frequency of occurrence occur automatically, whereas other processes such as imagery, rehearsal and phonemicals demand effortful attention. It is further proposed, that the attentional capacity of the individual is influenced by the physical arousal level.

The attentional control theory also proposed the perceptual narrowing of attention, occurs during periods of physical arousal.

1.8 Personality

Interestingly, personality dates back at least to the Greeks (Francis, 1993). As early as 1935, Allport and Odbert described traits as “generalized and personalized determining tendencies consistent and stable modes of an individuals adjustment to his environment”. (p.26). Current definitions are likely to reflect most of the above elements. Currently traits are defined as “Dimensions of individual differences in tendencies to show consistent patterns of thoughts, feelings and actions” (McCrae & Costa, 1990.p 23).

Theorists have begun to realize that the extensive research base on normal personality can help elucidate personality disorder
constructs. There is a consensus that a small number of broad dimensions describe the domain of normal personality (Watson, Clark & Harkness, 1994). It was in the early 1920’s the first widely used scheme for classification of personality disorders was used (Vaillant, 1987). He described ten varieties of abnormal personality, many of which roughly parallel DSM-Axis II diagnosis, he also introduced another important concept when he defined abnormal personality as variants of normal personality traits.

The Neuroticism, Extroversion Openness Personality Inventory-Revised (NEOPI-R) uses a trait dimensional approach. This approach builds upon the DSM-IV definition of personality disorders as traits, which are inflexible and maladaptive; however, there is an assumption of pathology per se. Rather, a common trait structure is used to describe both normal and pathological personality (Clercq & Fruyt, 2003).

The big five or Five Factor Model (FFM) is a classification of personality traits, originally discovered by examining the intercorrelations among adjective ratings across individuals. The FFM has a long history and is now associated with a number of researchers (including Costa & McCrae, 1990; Digman, 1990; Goldberg, W, 1959). Over the years there have been differences in interpretation of the factors; nonetheless the same general trait structure is being described (Goldberg, L. R. 1993; Watson, et al, 1994). Dimensions of the FFM include (1) Neuroticism vs emotional stability; (2) extroversion or surgency (3) Conscientiousness or will to achieve; dependability; (4)
agreeableness (frailng compliance) versus antagonism (Hostile non-compliance) (5) Openness to experience culture or intellect (Digman, 1990; Digman & Takemoto-Chock, 1981; Goldberg, L. R, 1990; McCrae & Costa, 1987).

The FFM is based on the notion that personality traits are organized hierarchies: these five super factors represent the highest level of organization, and provide a structural framework for more specific, lower order traits at intermediate levels of hierarchy (Digman, 1990; Goldberg, 1993; Watson, et al, 1994).

The FFM arose from what subsequently has become known as the lexical hypothesis described as the notion "that the most important individual differences in human transactions will come to be encoded as single terms in some or all of the world's languages." (Goldberg, L. R, 1993, p26). If the five factors are the fundamental dimensions of personality (McCrae, & John, 1992) and if personality disorders reflect maladaptive extremes of personality traits as suggested in DSM-IV, then the major traits that comprise a personality disorder should have specific representation within the FFM (Widiger, 1997). Several studies have demonstrated statistically significant associations between these five dimensions and personality disorder measures (Costa & McCrae, 1990; Wiggins & Pincus, 1989) in the general population. Studies of clinical samples have also demonstrated noteworthy relationships (Trull, et al, 2001; Clarkin, Hull, Cantor & Sanderson, 1993; Wilberg, Urunes Fris, Pederson, & Kaeterud, 1999). Factor structures consistent
within the FFM could be extracted from many different measures of personality pathology (Dyce & O'Connor, 1998a & 1998b).

### 1.9 OCD

In the literature on personality disorder, there is almost no mention of the relationship between body movements and personality (Berger, 1999). One aspect of this study explores the possible link between leg-shaking behavior and obsessions and compulsions.

The DSM-IV classifies OCD as an anxiety disorder because anxiety is the central concept in its definition; this is an American perspective that not all professionals around the world share. ICD-10 and related health problems, 10th edition (WHO 1992) defines OCD as a recurrence of a repetitive thought or act, recognized as senseless but accompanied by an irresistibleness and internal sense of compulsion (Freeman, 1992; Montgomery, 1992).

OCD involves several symptom clusters. In a factor analytic study of reported OCD symptoms (Lekman, et al, 1997) two independent samples yielded the same four factors: obsessions and checking, symmetry and order, cleanliness and washing and hoarding. Matiáx–Cols, et al, in 2002 found that adult patient's symptom subtypes remained relatively stable across a two-year period. Many people have experienced obsessions or compulsions to some degree. Rachman and De Silva (1978) found that the majority of a non-clinical sample reported unpleasant intrusive thoughts that were similar in content to obsessions in OCD. Muris, Merckelbach & Clavan (1997)
found that 55% of a non-clinical sample reported performing compulsive rituals. The non-clinical obsessions and compulsions were distinguished from OCD by their lower frequency and intensity, and the lower levels of distress caused by them (Muris et al., 1997; Rachman and De Silva 1978).

Normal vs abnormal obsessions and the use of non-clinical samples. Salzman (1973,1980) developed an early dimensional view of observing behaviour and argued for an obsessive spectrum that ranged from “Normal obsessional behaviour” to “Obsessional personality “to “Obsessional Neurosis”. To determine when a pattern of behaviour crosses the fuzzy threshold from “Odd but normal” to “abnormal” is a challenging task.

Relatively recent epidemiological and controlled studies have moved away from studying only patients diagnosed with OCD towards investigations of obsessional experiences in the broader population. Such work has revealed not only that OCD has a worldwide presence (Sternberger & Burns 1990) and that OCD has been found in all cultures that have been the subject of epidemiological study. But also that OCD like experiences were commonly endorsed by non-disordered samples and by children and adolescents (Flament, 1994).

This work subsequently, was repeated by independent investigators, interested specifically in non-clinical observations (Salkovskis & Harrison, 1984). Further additional reports suggest that non-clinical subjects who endorse high levels of OCD symptomatology are similar to OCD
patients in terms of cognitive deficiencies and concomitant psychopathology (Gibbs & Oltmanns, 1995). Muris, et al, (1997) concluded, "There is a continuity between abnormal and normal compulsions". And that the compulsions reported by non disordered subjects differed from those reported by OCD patients only in terms of frequency, intensity and their association with negative affect (p.249)

1.10 Study objectives and outline

This thesis is made up of multiple phases.

**Section 1:** Exploratory Naturalistic observation attempts to study the frequency and settings of leg-shaking.

**Section 2:** Examines whether there are, in fact, relationship between leg-shaking and personality traits, and two attention features.

**Section 3:** Attempts to understand the genetic basis of leg-shaking.

**Section 4:** Investigates the link between Cortisol and leg-shaking.

Chapter 1 introduces relevant basic concepts.

Chapter 2 attempts at a historical perspective.

Chapter 3 reviews literature in related fields.

Chapter 4 addresses the research question by formulating 17 hypothesis and describes design, sample selection methods and data analysis strategies.

Chapter 5 details results and discussion.

Chapter 6 ends with conclusion, limitation and future implication.

The thesis is then followed by glossary of terms not explained in the text, references, appendix and author index.