EXECUTIVE FUNCTIONING AND HABIT LEARNING IN CHILDREN WITH TOURETTE SYNDROME

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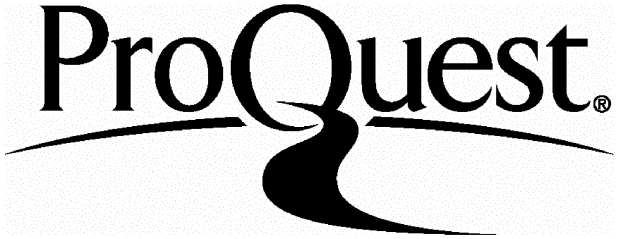

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ABSTRACT

Research suggests that individuals with Tourette Syndrome (TS) have impaired fronto-striatal neural systems. This study aimed to examine the performance of children with TS on a range of neuropsychological measures that are thought to involve the activation of fronto-striatal structures. Participants were twenty children with TS and twenty healthy children to act as a Control group, matched for age, sex and IQ. Data was also collected on symptomatology, including tic severity, symptoms of obsessive compulsive disorder (OCD) and attention deficit hyperactivity disorder (ADHD), social skills and childhood problems.

The main findings of the study were that the TS group performed significantly worse than the Control group on most of the tests of executive functioning used in the study. They were also impaired on the more sensitive tests of explicit memory used, which are thought to have an executive contribution. These results are consistent with existing research. There were no differences on tests of naming and perception, which are thought to be less reliant on executive skills. There were no significant differences between the groups on the priming and skill learning implicit tasks. Unfortunately, no studies of TS and implicit learning exist with which to compare this finding.

There were few significant associations between symptomatology measures and performance on tests. In order to explore the significant differences further, the TS group was divided into two subgroups, those with only TS and those with the co-

morbid conditions of OCD, ADHD or both. The co-morbid group performed significantly worse than the group with only TS on the explicit memory tests, but on only two of the six executive measures. Therefore, TS symptomatology itself appears to account for the many of the differences between the TS group and the Control group on executive measures.

The findings of this study suggest that the TS group were impaired on a range of executive measures. The lack of significant findings on the implicit learning measures suggests that habit-learning is intact. Consequently, it may be that executive problems account for the persistence of tics, in that once the tics are acquired they cannot properly be extinguished because the ability to inhibit responses is impaired. The implications for clinical interventions are considered on the basis of these findings.

1 INTRODUCTION

1.1 THE NATURE OF TOURETTE SYNDROME

Tourette syndrome (TS) is a neuropsychiatric condition, which begins in childhood and has a probable genetic aetiology (Sandor, 1999). The main characteristic of TS is bouts of tics, which occur many times a day. Tics are abrupt, sudden, jerky movements or vocalisations, which often mimic a normal co-ordinated movement. The number, frequency and complexity of the tics waxes and wanes over time.

A diagnosis of TS requires multiple motor tics and one or more vocal or phonic tics. Motor tics may be simple, such as eye blinking or arm jerking or complex, such as smelling things or skipping. Simple vocal tics may consist of throat clearing, while complex vocal tics can include whistling or barking. Other characteristic features include echolalia (the imitation of other people's speech), echopraxia (the imitation of other people's actions) and pallilalia (repetition of the last word, phrase or syllable). Typically, TS is associated with coprolalia (the involuntary inappropriate uttering or obscenities or blasphemous words, which may be disguised) and copropraxia (involuntary, inappropriate making of obscene gestures, such as the V-sign, often disguised). However, coprolalia occurs in only around 10% of individuals with TS, usually beginning around the age of fifteen.

1.2 DIAGNOSIS OF TOURETTE SYNDROME

In order to meet the criteria for a diagnosis for TS under DSM-IV, an individual must have experienced multiple motor tics and one or more vocal tics at some time during the condition. The tics must have occurred many times a day throughout a period of one year, during which there must have been a tic-free period of no more than three consecutive months. The onset must be before the age of eighteen and the disturbance must cause marked distress or significant impairment in social, occupational or other important areas of functioning. In contrast, the previous criteria for DSM-IIIR specified that the course should be waxing and waning, rather than there being a three month tic-free period. There was also no requirement that the symptoms caused marked distress or significant impairment.

A number of authors have expressed reservations about DSM-IV criteria (e.g. Comings, 1995; Freeman, Fast & Kent, 1995; Erenberg, 1996; Kurlan, 1997). In particular, there are concerns that the need for significant impairment or distress means that a diagnosis is made according to a subjective perception of disability, rather than neurological grounds. Impairment or distress is not a criteria for other movement disorders, such as stereotypic movement disorder or Parkinson's disease. There are also concerns that individuals who experience a tic-free period of more than three consecutive months throughout a period of one year do not meet criteria for a diagnosis and yet the natural course of the condition involves a waxing and waning of symptoms. Consequently, many patients with TS attending specialist clinics and in ongoing research studies may not now meet a diagnosis of TS, according to DSM-IV.

1.3 CO-MORBIDITY IN TOURETTE SYNDROME

TS can present with a wide range of symptoms, ranging from a few isolated tics to a severe and disabling condition, with many co-morbid features. Common co-morbid conditions include obsessive compulsive behaviour (OCB) or obsessive compulsive disorder (OCD) and attention deficit hyperactivity disorder (ADHD). Other difficulties, such as self-injurious behaviour, learning difficulties, conduct disorder, aggression, panic attacks, phobias, depression, mania and schizoid behaviours are not uncommon (Comings & Comings, 1987). However, there is a debate in the literature as to the nature of the relationship between other common co-morbid conditions and TS.

Around 50% of individuals with TS experience OCB (Shapiro, Shapiro, Young & Feinberg, 1988). The obsessions are often to do with thoughts about symmetry, counting and sex and violence. The compulsions are more concerned with counting, touching, checking and things being 'just right'. These differ to the obsessions and compulsions seen in Obsessive Compulsive Disorder (OCD) where the majority of obsessions are concerned with worries about dirt, germs and contamination or responsibility and harm and the majority of compulsions are concerned with excessive washing or checking (Robertson & Baron-Cohen, 1998). The co-morbidity between TS and obsessive compulsive symptomatology is generally accepted as having a genetic basis (Golden, 1990).

ADHD is commonly seen in individuals with TS. The characteristic features of ADHD are poor concentration, short attention span, being easily distracted, hyperactivity and impulsiveness. Over time, numerous diagnostic labels have been applied to this constellation of behaviours, including Hyperkinesis and Attention Deficit Disorder (ADD) with or without hyperactivity. The current diagnostic classification in DSM-IV of ADHD places greater emphasis on the hyperactive and impulsive features of the disorder and reflects the increasing empirical evidence that attention deficits and hyperactivity-impulsivity are two distinct dimensions, with differing levels of impairment, social and cognitive development and course. Consequently, DSM-IV now specifies four subtypes of ADHD: ADHD predominantly inattentive type, ADHD predominantly hyperactive-impulsive type, ADHD combined type and ADHD not otherwise specified. ADHD affects around 3-5% of the general child populations (Barkley, 1990), while as many as 50% of patients with TS in clinics have some form of ADHD (Comings & Comings, 1984, 1987). However, the association between TS and ADHD is more uncertain than the association with OCB because the results of genetics analyses have been inconclusive. Some authors see ADHD as representing a variable expression of TS (Comings & Comings, 1987; Kurlan, 1988). Others argue that they are independent entities and are transmitted separately, but if a child has both they are more likely to be referred to a specialist clinic (Pauls & Leckman, 1986; Shapiro, Shapiro, Young & Feinberg, 1988).

1.4 PREVALENCE AND COURSE OF TOURETTE SYNDROME

Research based on clinical populations suggests that the prevalence of TS is around 4-5 per 10,000. However, Mason, Banerjee, Eapen, Zeitlin & Robertson (1998) recently found the prevalence of TS to be as high as 3% in a mainstream school population. They suggest that there are large numbers of people with mild symptomatology and less co-morbid conditions who never become known to services. There is also a sex difference, with the male to female ratio about 2:1 (Leckman & Cohen, 1994).

The average age of the onset of symptoms is around seven years old, with the most frequent initial symptoms being excessive eye blinking or eye rolling (Robertson & Baron-Cohen, 1998). The onset of vocal tics usually occurs later than the motor tics, at the average age of eleven. Leckman, Zhang and Vitale (1998) studied a birth cohort of thirty-six patients who had been diagnosed with TS and found that tics appeared to be at their most severe at the age of ten years. By the age of eighteen years, 47% of patients were free of tics and tic severity at follow-up was associated with tic severity during the worst-ever period.

1.5 SUSPECTED NEUROPATHOLOGY IN TOURETTE SYNDROME

There is now a consensus that biological factors are the main contributors to the aetiology of TS, while psychological factors such as life stress and coping resources play a role in determining the course of the condition (Leckman & Cohen, 1994).

1.5.1 Genetics

Studies suggest that genetic factors are involved in TS in the majority of cases, but the precise mechanisms of inheritance are not known. Comings and Comings (1984) and Pauls and Leckman (1986) both found that the frequency of the gene is 0.006, suggesting that 1 in 83 people carry a TS gene. Most research suggests that the mode of transmission is autosomal dominance, with incomplete penetration (Pauls & Leckman, 1986). Therefore, the gene will be inherited by 50% of the offspring of an individual with TS, but they will not necessarily display the symptoms.

A genetic relationship with OCB has also been found and so if an individual inherits the gene, they may display OCB instead of or as well as TS (Comings and Comings, 1987). When OCB is included in the calculations, the hypothesis of a single autosomal dominant gene is strengthened. However, genetic analyses have also demonstrated that around 10% of cases of TS are phenocopies and not genetic in nature (Price, Kidd & Cohen, 1985). In these cases, the TS may be a result of the genes the individual possesses and the environment or genes that are not fully defined.

1.5.2 Neurotransmitters

The finding that haloperidol is effective in the treatment of many patients with TS led to the initial hypothesis that the functional abnormality might reside in the central dopaminergic systems (Golden, 1990). This hypothesis was supported by studies that found that homovanilic acid (HVA), a metabolite of dopamine, is decreased in the

cerebral spinal fluid of patients with TS (Comings, 1987). There is also evidence to suggest that dysregulation of noradrenergic and serotonergic systems and abnormalities in the functioning of endogenous opioid peptide systems may occur in TS (Carr, 1999).

1.5.3 Neuroimaging Investigations

A number of neuroimaging studies have found that metabolic rates in TS patients are significantly different to healthy control participants in certain areas of the brain, including the limbic system, basal ganglia and sensorimotor cortices. These areas are linked to each other by rich reciprocal connections.

Chase, Foster, Fedio, Brooks, Mansi, Kessler and Di Chiro (1984) found using PET scanning that there were no differences between healthy control participants and patients with TS in terms of the overall cerebral glucose metabolism. However, TS was associated with relative hypermetabolism in certain portions of the frontal and temporal lobes bilaterally, with glucose utilisation in the basal ganglia of TS patients 16% higher than control participants. They found a positive association between metabolism in the basal ganglia and metabolism throughout the cerebral cortex. Moreover, the cortical distribution of the regions in which glucose metabolism appeared to have a close inverse association with the severity of vocal tics clustered in the middle and the inferior portions of the frontal lobes bilaterally.

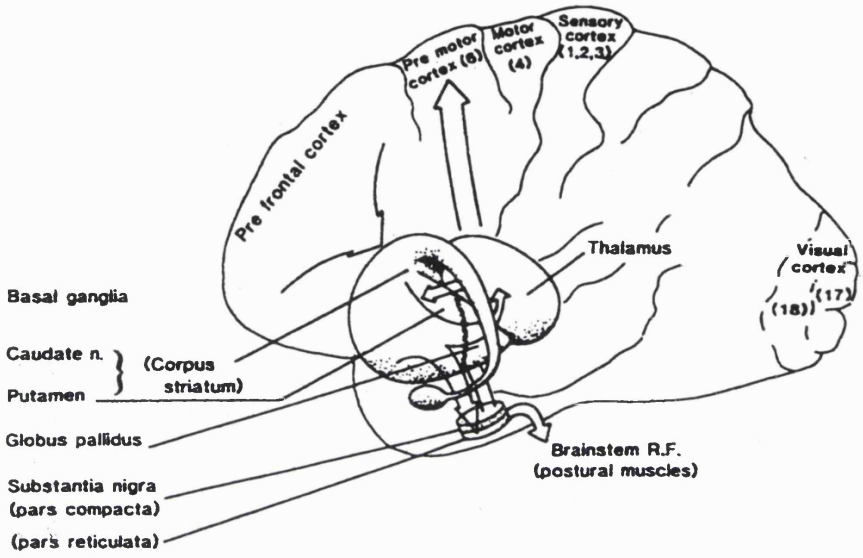
More recently, Stoetter, Braun, Randolph, Gernert, Carson, Herscovitch and Chase (1992) found that metabolic rates in TS patients were significantly different to control participants in the limbic system, basal ganglia and sensorimotor cortices. They found lower metabolic rates in inferior, limbic regions of the cortex, striatum and subcortical limbic structures. Higher metabolic rates were found in the superior sensorimotor cortices, which are involved in the regulation of movement and the premotor cortices, which are involved in complex integrative functions related to the organisation and initiation of movement. They suggest that altered functional relationships between inferior limbic and superior sensorimotor regions might characterise TS patients.

Peterson, Riddle, Cohen, Katz, Smith, Hardin and Leckman (1993) and Singer, Reiss, Brown, Aylward, Shih, Chee, Harris, Reader, Chase, Bryan and Denckla (1993) used MRI scanning to find evidence of structural abnormalities in the striatum. Both studies found an apparent volume reduction in the left lenticular nucleus and a loss of the normally occurring left-greater-than-right basal ganglia volumetric asymmetry. These volumes are consistent with previous evidence suggesting hypoplasia and hypofunctionality in the basal ganglia.

1.6 FRONTO-STRIATAL THEORIES OF TOURETTE SYNDROME

Figure 1 indicates the subdivisions of the frontal lobe and the connections to the striatal system.

Figure 1: The subdivisions of the frontal lobe and the connections to the striatal system.



Stoetter and colleagues (1992) have proposed a fronto-striatal theory of TS, based on their findings from PET scan investigations. They found that in normal control participants, when activity in the limbic region of the striatum increases, activity in the sensorimotor areas is normally depressed. However, in patients with TS, limbic and sensorimotor regions are activated simultaneously. This may represent a reversal of what is normally an inverse, perhaps inhibitory, relationship between this region of the striatum and cortical areas involved in the initiation of movement. The ventral striatum may be involved in the regulation of movement by coupling limbic and motor mechanisms. The mesolimbic dopamine system may serve a gating function at the level of the ventral striatum, regulating the flow of information from limbic structures to the pallidum, thereby governing response initiation. They argue that a

functional 'cross-wiring' of the basal ganglia-thalamo-cortical circuitry in the brain of TS patients results in a more direct connection between the putamen and limbic structures and between the ventral striatum and cortical regions directly involved in motor control.

Comings (1987) suggested two possible hypotheses to explain the findings of neuroimaging. One possibility is that the primary abnormality in TS is a genetic defect in either the mesocortical or prefrontal dopamine pathways, resulting in a disinhibition of prefrontal lobe functions and a compensatory increase in mesostriatal or mesolimbic dopamine pathways. Alternatively, there may be a genetic defect in both mesocortical and mesolimbic dopamine pathways causing disinhibition of prefrontal, striatal and limbic systems and resulting in dopamine hypoactivity in some areas and compensatory dopamine hypersensitivity in others.

However, the difficulty with these theories is the significance given to the 'reverberating' fronto-striatal loop. Leckman (1998) found that nearly half of his patients were free of tics by the age of eighteen and as yet, these models are not able to specify the factors that lead to the cessation of tics.

1.7 THE FRONTO-STRIATAL SYSTEM AND COGNITIVE ABILITIES

1.7.1 The Frontal Lobes

1.7.1.1 Executive functioning

Much of our understanding of the frontal lobes comes from the work of Luria (1966, 1973). The frontal lobe is divided into three major areas: the primary motor cortex, the premotor cortex and the prefrontal cortex. The prefrontal cortex has an executive function in that it is the site of interconnections and feedback loops between the major sensory and motor systems, linking and integrating all components of behaviour at the highest level. The prefrontal cortex "*attends, integrates, formulates, executes, monitors, modifies and judges all nervous system activities*" (Stuss and Benson, 1987). Luria (1973) described the division of the prefrontal cortex into lateral and basomedial regions. In the lateral portion, disturbances include the organisation of movement, the disintegration of motor programmes and the ability to compare motor behaviour with its original plan, depending on the location of the lesion. Disturbances to the basomedial region relate to the state of activation of the individual and their affective responses and control of inhibition.

More recent conceptual advances in understanding the role of the frontal lobes have focused on the role of cognition in behaviour to recognise how information-processing systems mediate learning. Norman and Shallice's (1986) Supervisory Attentional System (SAS) model of attentional control has been used to explain the behaviour of patients who have suffered frontal lobe injury. The model assumes that the processes involved in the cognitive control of action and thought occur on two

levels. On one level routine action or thought operations are carried out satisfactorily by well-learned triggering procedures. When these operations are novel, routine operations become insufficient and the lower-level system cannot solve the problem. At this stage higher level processes come into effective operation. There are a large and finite set of action and thought schemas that can each be activated if the respective well-learned triggers are excited. 'Contention Scheduling' is a lateral inhibitory mechanism which prevents two competing schemas being selected. The SAS modulates the activation level of schemas and biases their probability of being selected in Contention Scheduling in order to respond flexibly to novelty.

Within this model, if the SAS fails to increase the likelihood of competing schemas being activated, a person's behaviour may be dominated by the first impulse or stimulus that comes to mind. The decreased monitoring that results from damage to the SAS means that the output of the activated schemata is not necessarily inhibited or modified, which may lead to inflexibility and an inability to appreciate the consequence of one's actions. Norman and Shallice's model can be viewed as one possible realisation of Luria's theory in information-processing terms.

1.7.1.2 Memory

The role of medial temporal structures, including the hippocampus, in explicit memory is well established, with left and right sided structures mediating verbal and visual aspects of memory, respectively (e.g. Scoville & Milner, 1957; Dimsdale, Logue & Piercy, 1964). The importance of the human hippocampus and related

medial temporal structures in auditory-verbal memory is exemplified by amnesic patients who have selective lesions to this structure (e.g. Zola-Morgan, Squire & Amaral, 1986). However, neuropsychological studies have indicated functional specialisation in the prefrontal cortex for source, temporal sequencing and strategic organisational requirements in memory (Shimamura, Janowsky & Squire, 1991). More recently, evidence for the role of the prefrontal cortex in explicit memory comes from a number of studies using functional imaging.

Shallice, Fletcher, Frith, Grasby, Frackowiak and Dolan (1994) used PET to identify the areas in the brain associated with the acquisition and retrieval of episodic memory. They gave participants a dual-task paradigm to isolate brain areas associated with acquisition and a cueing paradigm to isolate areas concerned with retrieval from verbal episodic memory. They found that acquisition was associated with left frontal activity, whereas retrieval was associated with right frontal activity. In particular, they found the left dorsolateral prefrontal region to be associated with encoding and argued that it is likely that it plays a major role in the executive component of working memory and is involved in the organisation of supervisory thought processes. Although imaging did not reveal any hippocampal activation, the major reciprocal connection between the dorsolateral prefrontal region and the hippocampus involves the retrosplenial region and this was also activated during the encoding task.

Dolan and Fletcher (1997) used PET scanning to demonstrate hippocampal activation as well as prefrontal activation during the encoding of auditory verbal

material. They found evidence of functionally dissociable roles for the prefrontal cortex and hippocampal formation. Prefrontal activation reflected a relative emphasis on associative semantic processing which is necessary in establishing and maintaining new semantic linkages in the context of already established linkages, whereas hippocampal activation reflected relative novelty in the study material.

Dalla Barba, Parlato, Jobert, Samson and Pappata (1998) demonstrated prefrontal involvement in semantic as well as episodic memory. The two types of task activated both common and unique regions. Compared to episodic memory, the semantic memory tasks activated the superior temporal insular cortex bilaterally and the right premotor cortex, whereas compared to the semantic memory tasks, the episodic memory tasks activated the right frontal cortex. Both the semantic and episodic memory tasks activated the right prefrontal cortex.

1.7.2 The Striatal System

The striatal system consists of several complex motor correlation centres, the caudate and the putamen, that modulate both voluntary movements and autonomic reactions. Divac (1977) described how the neostriatum could be considered to be part of the system that translates cognition into action. Movement disorders, such as the muscular rigidity, motor slowing and tremor associated Parkinson's disease and the jerky, involuntary motions associated with Huntington's disease, are the most common and obvious symptoms of basal ganglia damage. However, there are also associated behavioural and cognitive changes. For example, in Parkinson's disease,

patients also suffer with problems in cognitive functioning, including short-term memory, concept formation and diminished mental flexibility (Huber and Cummings, 1992). In Huntington's disease, cognitive impairments typically involve attention, various aspects of memory and learning, language, visuo-spatial abilities, conceptual and generative thinking and significant personality changes.

Memory and learning disorders figure prominently among the cognitive deficits associated with the fronto-striatal system. Recent theoretical formulations and experimental evidence suggests that the fronto-striatal system may play an important role in at least some forms of implicit memory. In particular, it is implicated in the acquisition of motor, perceptual and cognitive skills and the development of stimulus-response habits (Butters, Salmon & Heindel, 1994; Saint-Cyr, Taylor & Lang, 1988). Haarland and Harrington (1989) suggested that the corpus striatum may serve as a memory buffer for established skills and response patterns and participates in the development of new skills for novel situations. With damage to the corpus striatum, cognitive flexibility and the ability to generate and shift ideas and responses is reduced (Eslinger and Grattan, 1989).

1.8 HABIT LEARNING AS AN EXPLANATION FOR THE AETIOLOGY OF TICS

In 1973, Azrin and Nunn put forward the hypothesis that tics could be seen as nervous 'habits', which are repetitive behaviours that serve no adaptive function (Woods & Miltenberger, 1995). These 'habits' may originally start as a normal

reaction, due to injury, trauma or an infrequent normal behaviour that has increased in frequency and altered in form. The behaviour becomes classified as a habit when it persists after the original injury or trauma has passed and when it is carried out at an unusually high frequency and in an unusual form. Under normal circumstances, the habit would be inhibited by personal or social awareness of its peculiarity or by its inherent inconvenience. However, the movement may have blended into normal movements so gradually that it escapes personal and social awareness and becomes part of a response chain that assumes a compulsive character. For some tics, the continuing execution of the movement may even strengthen the specific muscles required for that movement and the opposing muscles become relatively unused, causing difficulty for conscious inhibition of the tic and further contributing to the low level of awareness of the tic.

In 1990, Azrin and Peterson described a behavioural treatment for tics, called habit reversal, based on the idea that tics could be understood as habits. Habit reversal was designed to counteract these influences by the use of a competing response (e.g. isometric tensing of muscles) to prevent the tic and awareness training so that patients become aware of every occurrence of tics so that they are able to interrupt each movement. Habit reversal has been evaluated in several studies of TS and tics have found to be reduced by 55-100% (Azrin & Peterson, 1989/1990; Bullen & Hemsley, 1983; Finney, Rapoff, Hall & Christopherson, 1983; Peterson & Azrin, 1992; Zikis, 1983). Over time, habit reversal appears to have led to a greater reduction in tics than self-monitoring or relaxation (Peterson & Azrin, 1991). It has

also been more successful than massed negative practice, in which the patient reproduces the tic rapidly in order to reduce tension (Azrin & Nunn, 1973).

However, there are numerous methodological difficulties with this research. Most of this research is based on case studies of between one and three participants. There is often little information on diagnostic criteria and tic changes and follow-ups often take place after only a relatively short duration. There is a lack of observer reliability measures and rarely any symptom severity or tic frequency measures. In addition, the success of a particular treatment can only ever provide indirect evidence of the validity of the hypothesis.

1.9 THE ACQUISITION OF HABITS THROUGH IMPLICIT LEARNING

The mechanism by which habits are thought to be acquired is implicit learning. Schachter, McAndrews and Moscovitch (1988) define implicit memory as "*knowledge that is expressed in performance without subjects' phenomenal awareness that they possess it*". As mentioned earlier, some forms of implicit learning are believed to rely on the fronto-striatal system, which is thought to be impaired in TS. This throws some doubt on the hypothesis that tics are acquired through habit learning.

A conceptual distinction has been drawn between explicit (or declarative) memory, which involves the conscious recollection and recall of episodes and factual

information, and implicit (or procedural) memory, which is thought to be acquired incidentally by relatively automatic processes with minimal involvement of attentional resources. Stimuli in implicit memory experiments are typically consciously perceived by the participants, but the effect of the experience is shown by participants without them necessarily recalling the learning situation explicitly. This contrasts with typical explicit memory experiments that invoke conscious or deliberate recollection of recent episodes, as in standard recall and recognition tests.

There are thought to be three main categories of implicit learning: skill learning (motor/cognitive skill and perceptual 'how to' learning), priming (where prior exposure facilitates the response, without the person's awareness) and classical conditioning. However, the dichotomy between implicit and explicit learning may be an oversimplification and it is likely that the processes underlying priming, classical conditioning and motor skill will be quite different to each other. PET studies suggest that these different types of learning are associated with activation in different areas of the brain. Skill learning is thought to involve striatal activation (e.g. Mishkin, Malamut & Bachevalier, 1984), tests of priming involve frontal activation (e.g. Squire, Ojemann, Miezin, Petersen, Videen & Raichle, 1992; Keane, Gabrieli, Fennema, Growdon & Corkin, 1991) and tests of classical conditioning involve the cerebellum (Lezak, 1995).

Research suggests that there are a number of important characteristics in the way implicit memory tasks are performed. Implicit memory seems to be very much tied to the surface characteristics of stimuli and a number of studies have found that

performance on implicit tasks is substantially reduced by a modality shift from learning to testing, e.g. auditory to visual. For example, Bassili, Smith and MacLeod (1989) reported that priming effects on word completion tasks were significantly reduced by a study test modality shift whereas recall and recognition performance was largely unaffected. Implicit memory also appears to show a slower decay over time than explicit measures (Jacoby & Dallas, 1981).

Performance on implicit memory tasks also does not appear to be affected by variations in the depth of study processing. Jacoby and Dallas (1981) assessed implicit and explicit performance following a study task that required elaborative processing, e.g. answering questions about the meaning of the words, and non-elaborative processing, e.g. deciding whether or not the word contains a specific letter. They found explicit memory was better under the elaborative condition, but there was no difference in the implicit tasks.

Tulving (1985) argued that implicit memory is stochastically independent of explicit memory. That is, the probability of success on a measure of implicit memory is unrelated to success or failure on explicit memory. Furthermore, Hayman and Tulving (1989) found that, unlike explicit memory tests, different types of implicit memory tests were stochastically independent of each other.

1.9.1 Dissociations between Performance on Implicit and Explicit Tasks

Studies of patients with neuropsychological deficits have tended to support the notion that there is a distinction between implicit and explicit processing. These studies have frequently demonstrated that patients with various lesions and deficits show implicit knowledge of stimuli they cannot explicitly perceive, identify or process semantically. Milner's (1962) study of HM, a patient with amnesia following a bilateral temporal lobectomy, was one of the first and most often cited examples of intact implicit memory. She demonstrated that HM could acquire motor skills, such as pursuit rotor and mirror tracing, despite that fact that he could not remember explicitly performing the tasks on previous occasions.

Over the years this finding has been replicated with groups of amnesic patients. Cohen and Squire (1980) showed that amnesic patients acquired the skill of reading mirror inverted script at the same rate as control participants. However, the amnesics could not explicitly remember the prior occurrence of the target materials. Nissen and Bullemer (1987) tested amnesics on a serial pattern learning task, in which participants were exposed to a spatial array of lights and had to press a key beneath each light when it was activated. They found that amnesics and control participants responded more quickly when the lights were activated according to a repeated serial pattern, rather than randomly. Again, the amnesics were severely impaired when asked to remember the sequence explicitly. Weiskrantz & Warrington (1979) found intact conditioning in amnesics and Graf & Schachter (1985) found that amnesics also performed normally on a word completion test of priming.

The capacity of amnesic patients for cognitive skill learning is less well understood. Cohen, Eichenbaum, Deacedo and Corkin (1985) initially reported that performance on the Tower of Hanoi task was intact with patient HM and other amnesic patients. However, Butters, Wolfe, Martone, Granholm and Cermak (1985) failed to replicate this. Gabrieli, Keane and Corkin (1987) suggested that the original observation of normal acquisition by amnesic patients was dependent on the frequent use of prompts and cues during learning. Although Glisky, Schachter and Tulving (1986) were able to teach amnesics computer skills, they found it was at an abnormally slow rate. It has been suggested that many of these tasks depend on explicit as well as implicit memory capacity (Shimamura & Squire, 1988).

This is a problem with these studies, in that it is not always clear whether particular tests are 'pure' implicit tests or whether they also involve explicit learning. Another difficulty in making comparisons between amnesics or other patient groups and control participants is that controls can typically use both implicit and explicit learning even when the test is designed to measure implicit learning. Shanks and St. John (1994) have argued that the methods by which researchers assess explicit knowledge have not been agreed upon. They also argue that random stimuli in the experiments may not be random and some stimuli occur with greater probability than others. There are also difficulties disentangling the involvement of other related concepts of attention and awareness.

It may also be the case that tests designed to measure explicit memory also have some implicit involvement. Jacoby's (1991) process-dissociation model suggests that

remembering involves both habit, which is automatic responding, and recollection, which is the consciously controlled use of memory. This distinction is similar to the one made between implicit and explicit learning. Hay and Jacoby (1996) argue that if habit produces the same response as recollection, it facilitates performance by leading to a correct response. Errors in performance occur when habit and recollection are opposed and failures in recollection lead to the habit response. These errors are more likely to take place when people are required to respond rapidly and respond on the basis of habit rather than recollection. They argue that memory difficulties often arise at the level of elaborative encoding rather than retrieval and result from a failure to recollect an event when speeded responding is required.

1.9.2 Dissociations between Performance on Different Implicit Tasks

As well as dissociations between performance on implicit and explicit tests, there are marked dissociations between different forms of implicit learning in different disorders. Specific pathology appears to be important in understanding the dissociations between different forms of implicit learning in disorders involving different areas of the brain. Typically, patients with Alzheimer's disease are impaired on word stem completion tasks. For example, Heindel, Butters and Salmon (1988) found that patients with Alzheimer's Disease have shown little lexical and pictorial priming, but performed as well as control participants on motor skill learning. Alzheimer's disease is thought to affect many neocortical areas and it has been suggested that these difficulties in word priming can be attributed to damage in posterior association areas, which are thought to store lexical and semantic representations (Shimamura, Salmon, Squire & Butters, 1987).

In contrast, patients with Parkinson's disease and Huntingdon's disease show little motor skill learning, but intact lexical and pictorial priming. For example, Jackson, Harrison, Henderson and Kennard (1995) and Willingham and Koroshetz (1993) found both patient groups showed impaired sequence learning, while Saint-Cyr, Taylor and Lang (1988) found patients with Huntington's disease showed little cognitive skill learning, on the Tower of Hanoi test. Both diseases are associated with striatal abnormalities: Parkinson's disease is associated with severe neuronal loss in the substantia nigra, whereas Huntington's disease is associated with lesions in the striatum, particularly in the caudate nucleus (Lezak, 1995).

1.10 NEUROPSYCHOLOGICAL FINDINGS IN TOURETTE SYNDROME

Over the last twenty years, a number of studies have investigated the performance of children and adults with TS on a range of neuropsychological measures, including intellectual functioning, memory and executive functioning.

1.10.1 Intellectual Functioning and Hemisphere Asymmetries

Many of the early studies of TS administered tests of intellectual functioning, such as the WAIS-R (Wechsler, 1981), to examine levels of intelligence and whether there were any differences in Verbal (VIQ) and Performance IQ (PIQ). They found IQs to be broadly within the average range (e.g. Thompson, O'Quinn & Logue, 1979; Incagnoli & Kane, 1981; Bornstein, King & Carroll, 1983, Bornstein, 1990, Bornstein, Baker, Bazylewich & Douglass, 1991; Brookshire, Butler, Ewing-Cobbs

& Fletcher, 1994). However, several studies have reported large discrepancies between Verbal IQ and Performance IQ. Five studies (Izmeth, 1979; Incagnoli & Kane, 1981; Bornstein, King & Carroll, 1983; Shapiro, Shapiro, Young & Feinberg, 1988; Bornstein et al, 1991) examined the proportion of the sample demonstrating discrepancies of fifteen points or more, and found discrepancies in 25-55% of the sample. Individual authors have suggested that these discrepancies indicate lateralised cerebral dysfunction in TS. However, there were no clear patterns of discrepancy in these studies overall, with neither Verbal nor Performance IQ consistently higher than the other. In addition, the WAIS is a poor index of lateralised dysfunction. Many of these early studies have very small samples (e.g. Thompson et al, 1979), which may limit the generalisability of the results and subsequent conclusions. More recently, studies have not found any discrepancies between VIQ and PIQ at all (e.g. Bornstein, 1991, Brookshire et al, 1994).

It may be that these inconsistencies could be explained with respect to the heterogeneity of TS. The criteria for diagnosis are often not provided, which raises questions about accurate identification or severity of symptoms. In many of the studies, there are no measures of co-morbid conditions, such as OCD or ADHD, which may be contributing to the results. Dykens, Leckman, Riddle, Hardin, Schwartz and Cohen (1990) studied 30 children with TS, 19 with ADD and 11 without ADD. They found the TS/ADD group had significantly lower PIQs than the TS-only group. Although this study also has a small sample size, the results suggest that the presence of ADD may account for some variation in intellectual functioning in TS. However, Yeates and Bornstein (1994) did not find ADD in TS to be

associated with differences in IQ. De Groot, Yeates, Baker & Bornstein (1997) found children with TS and co-morbid OCB and OCB/ADHD had significantly lower VIQs than a group with TS only. The group with OCB and ADHD performed worse than the group with OCB. These inconsistencies in the research make it difficult to draw any conclusions. There may be a relationship between co-morbid conditions and performance on Verbal and Performance tests of intellectual functioning, but the relationship is not clear.

Bornstein and Yang (1991) investigated the effect of neuroleptic medication on cognitive performance. They examined the performance on a battery of neuropsychological measures of 51 children taking medication and 45 children not on medication, matched for age, sex and duration of symptoms. They found that there were no substantial adverse effects of medication on intellectual and more broadly, neuropsychological performance.

1.10.2 Spatial, Motor and Graphic Skills

A number of early studies have consistently reported abnormalities on tasks involving spatial, motor or graphic skills in participants with TS (Thompson, O'Quinn & Logue, 1979; Incagnoli & Kane, 1981; Bornstein, King & Carroll, 1983). Tasks commonly found to be impaired in TS patients have included measures of psychomotor problem-solving, written arithmetic, complex abstract reasoning, visual attention span, dexterity and graphesthesia.

More recently, studies have found that while the majority of participants perform within the normal range on neuropsychological measures, there appears to be a significant subgroup of approximately 20% who demonstrate significant neuropsychological impairment on spatial, motor and graphic skills. Bornstein (1990) tested 100 children and found that around 20% performed poorly on sensory-perceptual tasks and some psychomotor tasks. Bornstein (1991a) tested 36 adults with TS and also found 18% obtained a score on the Halstead-Reitan battery that would be defined as 'impaired'. There is some evidence that a poor performance on these tests is related to later age at onset of symptoms, the existence of complex tics (Bornstein, 1990) or symptom severity (Bornstein, et al, 1991). Bornstein et al (1991) also found that poor performance related to levels of urinary phenylethylamine (PEA), a neuromodulator involved in sustaining attention and mood. Lower levels of PEA were associated with a greater number of TS symptoms and worse performance on tests of motor speed, problem-solving and sensory-perceptual skills.

Randolph, Hyde, Gold, Goldberg and Weinberger (1993) tested 12 pairs of monozygotic twins in order to determine whether there was a relationship between tic severity and neuropsychological function in TS. On most measures, subjects' performances were close to normal means. In each twin pair, the twin with the more severe tic symptoms was found to have a lower global neuropsychological score than their other twin. They performed worse on tests of visuo-spatial perception and motor function. There was no relationship between ADHD severity or breadth of

symptoms and performance. They suggest that the non-genetic factors that influence tic severity exert a similar effect on neuropsychological function.

One of the difficulties with many of these studies is that few include a matched control group and so interpretations have been based on participants scoring in the 'impaired' range on tests. Many of these studies have drawn their conclusions from impaired performance on the Halstead-Reitan battery and it is not clear whether studies have used early norms, which were criticised for producing spuriously inflated Impairment Indices. In response to these problems, Schultz, Cater, Gladstone, Scahill, Leckman, Peterson, Zhang, Cohen and Pauls (1998) carried out a study to provide a clear test of the hypothesis that children with TS exhibit relative deficits in visual-motor integration skill, compared with a matched control group. They also assessed the role of ADHD and depression in performance. Consistent with previous studies, they found that the majority performed within normal limits on the tests, with only a subsample showing clinically meaningful impairments and there were significant differences on visual-motor tests between children with TS and matched control participants. The children with TS performed significantly worse on a visual-motor integration test and there was a trend towards significance on the Rey Osterrieth Figure. They found no evidence to suggest that comorbid ADHD or depressive symptomatology could account for the group differences. They concluded that children with TS appeared to experience difficulties in the areas of fine motor skill, visuoperceptual abilities and response inhibition, but they did not appear to be impaired in terms of sustained attention. They suggested that the integration of

sensory and motor processes appears to be a fundamental consequence of TS, perhaps arising from abnormalities in the caudate nuclei.

However, these differences may also reflect the involvement of executive function. For example, a number of studies have documented that the use of a strategy in carrying out the Rey Osterrieth Figure Test bears a significant relationship to how well the figure is recalled (e.g. Shorr, Delis & Massman, 1992). In general, if the task is approached conceptually, by dealing with the overall configuration of the design first and then the details second, individuals tend to do better than if the details of the task are copied one by one, even if this is done systematically. Another of the tasks used required participants to write down the answers to a set of arithmetic problems over a ten-minute period and so performance could be affected by the inability to sustain attention for this time period, as well as difficulties with calculation. Consequently, some of these results could be consistent with the fronto-striatal hypothesis of TS and could be accounted for by impairments in executive function.

1.10.3 Memory

There have been very few studies looking at memory performance in participants with TS. Bornstein (1991a) found that participants with TS performed normally on tests of verbal and visual recall memory. The most comprehensive study appears to be that of Stebbins, Singh, Weiner, Wilson, Goetz & Gabrieli (1995), who carried out a study to investigate memory functioning in unmedicated adult TS patients. They administered a battery of memory tests, including tests of implicit and explicit

memory. As hypothesised, the TS group was impaired on the rotary pursuit motor skill-learning test, which is consistent with the location of structural and functional CNS abnormalities in the fronto-striatal system. The TS group did not differ from the Control group on immediate memory span or on a recognition task that involved selecting which word from 24 word pairs they had seen before. However, on a more complex recall test, in which participants had to read a list of 24 words aloud and then recall them, the TS group performed worse than the Control group. Criteria for exclusion included a diagnosis of ADHD, although it is not clear whether any participants had co-morbid OCD and this may have had a confounding effect.

1.10.4 Executive Function/Attention

A number of studies have been carried out to investigate executive functioning in TS and have found impairments in areas such as sustaining attention, focusing and shifting set and inhibition. Again, these results are consistent with the fronto-striatal theory of TS. Attempts have been made to relate these impairments to the presence of co-morbid conditions.

Channon, Flynn and Robertson (1992) tested 19 adults with TS and 22 control participants to study attentional problems. The adults with TS performed worse than the Control group on several tasks, including serial addition, block sequence span, Trail Making and a letter cancellation task. Impairments were found in sustaining attention and in focusing and shifting set between salient stimuli. The authors suggested that this may be contributing evidence towards the hypothesis that frontal-

subcortical systems may be involved in the pathophysiology of TS. The TS group reported significantly greater depressed mood, anxiety and obsessional symptoms relative to the Control group, but there were no significant correlations between these measures and tests of attention. Medication did not appear to play an important role in producing effects on cognitive function.

In Randolph et al's (1993) study of monozygotic twins, the Continuous Performance Test, a measure of sustained attention and freedom from distractibility, was the most sensitive in discriminating between groups, with the twin with the more severe tic symptoms performing significantly worse.

Baron-Cohen, Cross, Crowson and Robertson (1994) administered two tasks that required participants to inhibit one intention, while executing another simultaneously activated intention. One task was in the motor domain and the other was in the language domain. A group of children with TS were compared to four control groups of children, aged 3 to 6 years old. Despite being older, the TS participants performed worse than the group of 6-year-olds on both tasks. The authors suggest that children with TS suffer from a specific cognitive deficit in the 'Intention Editor', which inhibits one intention while executing another. At the very least, this appears to suggest that the errors made by the children with TS reflect attentional problems and a general loss of inhibition.

Georgiou, Bradshaw, Phillips & Chiu (1996) examined the efficiency with which TS patients could hold and shift attention between expected and unexpected spatial locations. They also tested patients with Huntington's Disease, in which similar neurological structures are affected. Both groups were compared to a control group, matched for sex, age, IQ and mental status. They found that both the TS and Huntington's disease patients were considerably slower than control participants in responding to unexpected rather than expected stimuli on a Choice Reaction Time Test, although the TS group was not very much more disadvantaged than the Control group in making attentional shifts. They conclude that the attention deficit observed in TS may represent a specific problem with respect to difficulties in shifting the focus of attention.

Shucard, Benedict, Tekok-Kilic and Lichter (1997) examined the performance of TS children and normal children on the Continuous Performance Test. The TS children demonstrated a normal capacity for discriminating targets from non-targets during the task, but showed significantly slower reaction times than control participants. Only severity of complex vocal tics was predictive of reaction time performance. The authors suggest that TS patients are able to sustain attention as well as control participants. However, their slower reaction times may reflect attentional dysfunction, motor dysfunction or both in TS. The significant relationship between tic severity and reaction time is consistent with other studies (Bornstein et al, 1991; Randolph et al, 1993). This relationship may support the possibility that these disturbances have a common pathophysiological mechanism. Alternatively, the

presence of tics during task performance could interfere with participants' responsiveness.

A number of studies have found that both OCD and ADHD emerged as contributors to impairments in tests of executive function in TS. Bornstein (1991b) found that children with TS, with high scores on a measure of OCD, performed significantly worse on the Wisconsin Card Sort Test than a group with low scores on the OCD measure. Yeates and Bornstein (1994) found that children with TS and ADHD performed significantly worse than those with just TS on measures thought to reflect specific elements of attention, especially encoding, sustaining and focusing. Silverstein, Como, Palumbo, West & Osborn (1995) found that there was greater variability among TS and ADHD groups on two tasks of attention (Span of Apprehension and Digit Symbol substitution). The authors suggest these groups may be impaired in the focusing-executing component of attention.

Harris, Schuerholz, Singer, Reader, Brown, Cox, Mohr, Chase & Denckla (1995) found that executive function, as measured by the Rey Osterrieth Complex Figure, was significantly worse in the TS and ADHD group, than the TS only group. They suggest that non-verbal planning, self-monitoring and other premotor impairments are associated with ADHD or the combination of TS and ADHD, but not with TS itself.

De Groot, Yeates, Baker & Bornstein (1997) found that on measures of executive function, the two groups with OCB performed significantly worse than the TS only group, with the TS/OCB/ADHD performing worse than the TS/OCB group. The TS/OCB/ADHD group was more impaired than the other groups on all the measures where significant differences were obtained. Therefore, the authors argue that the co-occurrence of OCB and ADHD may explain a relatively specific abnormality on executive function tasks rather than OCB or ADHD symptoms alone with TS.

However, other studies have not found OCB/OCD or ADHD to be significant contributing factors. Channon, Flynn and Robertson (1992) did not find a relationship between obsessional symptoms and performance on tests of attention. In Randolph et al's (1993) study of monozygotic twins, there was no relationship between ADHD severity and performance on attentional measures. Yeates and Bornstein (1994) found no differences between children with TS with and without ADHD on the WCST. De Groot, Yeates, Baker & Bornstein (1997) found that although there were trends towards impairment, the TS/ADHD group was not significantly more impaired on any measure of executive function than the TS or TS/OCB symptoms groups.

As with tests of intellectual functioning, there appears to be a relationship between OCB/OCD and ADHD and performance on tests of executive functioning, but the relationship is not clear. It may be that OCB/OCD, ADHD or the combination of both of them may contribute to performance on executive tests in more specific ways. For example, obsessional symptoms may be implicated more in shifting

attention, whereas ADHD may be more related to sustaining attention. However, breadth of symptoms and medication do not appear to contribute towards impairments in executive tests (Bornstein, 1991; Randolph et al, 1993).

1.10.5 Summary of Neuropsychological Findings

Studies of TS have found IQs to be broadly within the average range. While some studies have found large discrepancies between Verbal and Performance IQs, there are no clear patterns of discrepancy and many studies have found no discrepancies at all. There appears to be a relationship between OCB/OCD and ADHD and performance on Verbal and Performance tests of intellectual functioning, but the relationship is not clear. However, there do not appear to be any substantial adverse effects of medication on intellectual and more broadly, neuropsychological performance.

Studies have found that while the majority of participants perform within the normal range on neuropsychological measures, there appears to be a significant subgroup of approximately 20% who demonstrate significant neuropsychological impairment on spatial, motor and graphic skills. There is some evidence that a poor performance on these tests is related to later age at onset of symptoms, the existence of complex tics, symptom severity, greater number of symptoms and lower levels of PEA. There is no evidence to suggest that comorbid ADHD or depressive symptomatology can account for these differences. So far, studies have not looked at the relationship between OCB/OCD and impairments on these tasks.

Very few studies have investigated memory functioning in TS. Initial findings suggest impairments on an implicit motor skill learning task, although the evidence for impairments on explicit memory tests is mixed.

A number of studies have been carried out to investigate executive functioning in TS and have consistently found impairments in sustaining attention, focusing and shifting set. As with tests of intellectual functioning, there appears to be a relationship between OCB/OCD and ADHD and performance on tests of executive functioning, but the relationship is not clear. It may be that OCB/OCD, ADHD or the combination of them may contribute to performance on executive tests in more specific ways. Tic severity, breadth of symptoms and medication do not appear to contribute towards impairments in executive tests, although tic severity does appear to have a significant relationship with reaction time, with a greater number of tics associated with a slower performance.

Together, these impairments on executive tasks, an implicit task and graphic/motor tasks could be seen as evidence for the deficits predicted by the fronto-striatal dysfunction theory of TS.

1.11 NEUROPSYCHOLOGICAL FINDINGS IN CO-MORBID CONDITIONS

Pennington and Ozonoff (1996) carried out a review of published neuropsychological studies on ADHD and found that fifteen of the eighteen studies found a significant difference between an ADHD group and a Control group on one or more executive measures. Measures that appeared especially sensitive to ADHD were the Tower of Hanoi, the Stroop, Part B of the Trail Making Test, Matching Familiar Figures Test and measures of motor inhibition, such as Go No-Go. They were also consistently poorer on measures of vigilance and perceptual speed. On ten of the thirteen studies reviewed, there were no significant group differences on verbal memory tasks between the ADHD group and control group and only four out of nineteen studies found group differences on visuo-spatial measures, including memory.

Neuropsychological findings in OCD have included executive deficits in cognitive set shifting (e.g. Aronowitz, Hollander, DeCaria, Cohen, Saoud, Stein, Liebowitz and Rosen, 1994; Head, Bolton & Hymas, 1989; Harvey, 1986), attention and memory difficulties (e.g. Aronowitz et al, 1994; Constans, Foa, Franklin & Mathews, 1995), non-verbal memory deficits (e.g. Boone, Ananth, Philpott, Kaur & Djenderedjian, 1991; Tallis, Pratt & Jamani, 1998), and visuospatial and visuo-constructional impairments (e.g. Christensen, Kim, Dysken & Hoover, 1992). However, much of the early work was conducted on non-clinical or sub-clinical samples, sample sizes are often small and many of the studies do not include control groups. This literature

and the literature on ADHD and TS demonstrate consistent impairments in executive functioning, which may reflect fronto-striatal pathology in all three conditions.

1.12 MODEL FOR THE PRESENT STUDY

Research suggests that TS could be considered as a habit. However, studies also suggest people with TS have impaired fronto-striatal neural systems and the striatal system is often linked to habit learning. On the whole, this is supported by the neuropsychological literature that found impairments in an implicit task, motor tasks and executive tasks. Rather than suggesting that habit learning is an etiological factor in the condition, this is more consistent with the argument that habit learning will be impaired in TS. However, the two may not be mutually exclusive; for example, it may be that habits are learned normally, but there is a limited repertoire or they cannot be properly extinguished. So far, little attention has been given to develop explanatory models or processes that could account for associations with performance on neuropsychological tests.

It is suggested that TS is associated with striatal dysfunction, which will lead to some deficits in implicit (habit) learning. The condition is also associated with frontal impairment and it is hypothesised that this will lead to difficulties in inhibition, which will also have an effect on habit learning. However, these impairments are not thought to be global; therefore, people with TS should perform normally on tests which are not directly associated with fronto-striatal functioning.

1.13 AIMS AND HYPOTHESES

This study is concerned with cognitive impairments in TS. The aim is to develop an explanatory model or process that could account for associations with performance on neuropsychological tests. The following hypotheses will be addressed:

1. Children with TS will perform worse than control children on tasks of executive functioning.

2. Children with TS will perform worse than control children on tasks of explicit memory, because of the involvement of executive functioning in these tasks.

3. Children with TS will perform worse than control children on implicit tasks involving skill learning and priming.

4. The performance of children with TS on tasks that are not thought to be directly dependent on the fronto-striatal system, including naming and perceptual tasks, will not be significantly different to the children in the normal control group.

2 METHODOLOGY

2.1 DESIGN

A group of young people with TS was compared to a group of healthy control participants using a mixed between-and-within subjects design.

2.2 PARTICIPANTS

Forty young people participated in this study. The TS group and Control group were matched for sex, age and intellectual ability, estimated from scores on the Graded Word Reading Test (Schonell, 1976) and Raven's Standard Matrices (Raven, 1960).

2.2.1 Tourette's Group

The young people with TS were recruited through the specialist clinic for Tourette syndrome at the National Hospital for Neurology and Neurosurgery. Participants were included if they met DSM-III R criteria for TS. They also had to be between 8 and 18 years of age, with English as their first language.

Participants were excluded from the study if they had learning difficulties, a neurological or psychiatric disorder (other than OCD or ADHD) or a significant history of alcohol or drug abuse.

2.2.2 Control Group

The young people in the Control group were recruited from local schools and colleges. The same criteria for exclusion were used for the Control group as the TS group. The Control group was also screened for the presence of motor or vocal tics, OCD and ADHD.

2.2.3 Sample Characteristics

As indicated in Table 2.1, groups were matched on age and intellectual ability, estimated from scores on the Graded Word Reading Test and Raven's Standard Matrices. They were also matched for sex, with both groups containing 13 boys and 7 girls.

Table 2-1 Sample characteristics

	Tourette's Group (n = 20)		Control Group (n = 20)			
	Mean	S.D.	Mean	S.D.	T value	Sig.
Age	13.60	(2.62)	13.55	(2.52)	.06	.951
Graded Word Reading Test	75.60	(16.69)	79.70	(11.59)	.90	.372
Raven's Standard Matrices	39.30	(8.63)	41.75	(6.83)	.99	.326

As indicated in Table 2.2, the mean age of onset for the TS group was just under six years old. The mean Yale Tic Severity Score was 29.80, which is in the mild range. Of the TS group, 2 participants had a diagnosis of TS and OCD, 6 participants had a

diagnosis of TS and ADHD and 3 participants had a diagnosis of TS, OCD and ADHD.

Table 2-2 Characteristics of Tourette's Group.

	Tourette's Group (n = 20)	
	Mean	*S.D.*
Age of onset	5.90	(3.45)
Yale Tic Severity Score	29.80	(19.45)

2.3 MEASURES

2.3.1 Measures of Symptomatology

2.3.1.1 Yale Global Tic Severity Scale (YGTSS) (Leckman, Riddle, Hardin, Ort, Swartz, Stevenson & Cohen, 1989)

The Yale Global Tic Severity Scale is rated by the clinician and measures the severity of both motor and phonic tics. Tics are measured in terms of number, frequency, intensity, complexity and interference over the previous week, and intensity for each item is rated on a scale of 0-5. The level of overall impairment is also rated and then multiplied by 10. A global severity score out of 100 is calculated by summing the total motor and phonic scores and the overall impairment score.

2.3.1.2 Motor tic, Obsession and Compulsion and Vocal tic Evaluation Survey (MOVES) (Gaffney, Sieg & Hellings, 1994)

The MOVES is a self-report scale and contains 16 basic statements that describe 4 main symptoms: motor tics, vocal tics, obsessions and compulsions. There are 4 statements for each of the 4 symptoms and each statement is answered on a scale of 0-3, in terms of its frequency. The motor and vocal tic items can be subdivided into simple and complex tics. The measure includes 5 subscales: motor tics, vocal tics, obsessions, compulsions and associated symptoms (echolalia, echopraxia, coprolalia and copropraxia). Subscale scores can be combined to form a Tic Subscale or an Obsessive-Compulsive Subscale. The MOVES appears to have good reliability and validity and was able to distinguish between a TS group and a psychiatric and normal control group, with good sensitivity and specificity (Gaffney, Sieg & Hellings, 1994).

2.3.1.3 Child Behaviour Checklist (CBCL) – Parent Form (Achenbach, 1991)

The Child Behaviour Checklist is a well-standardised measure, which has forms to be completed by parents, teachers and young people aged 4-18. In this study, the parent rating form of the CBCL was used. This measures a wide range of problem areas, including withdrawal, somatic complaints, anxiety/depression, social problems, thought problems, attention problems and aggressive behaviour. There are subscale scores for internalising behaviours, such as depression and anxiety, and externalising behaviour, such as conduct problems, as well as a social competence score. The scores provide a profile of the child's behaviour relative to other children

of the same age and sex. In the present study, the internalising and externalising subscores were the measures used.

2.3.1.4 Leyton Obsessional Inventory – Child Version (LOI-CV) (Berg, 1989)

The Child Version of the Leyton Obsessional Inventory was designed to identify obsessive patients and to quantify changes in symptoms during treatment. It was modified from the adult version and consists of 20 self-rated items. Items were added that were more suitable for a younger population, concerning schoolwork and magic games and wording on items was simplified. Each item is scored 'yes' or 'no' and then all items answered 'yes' are rated for interference on a scale of 0 ('this habit does not stop me from doing other things I want to do') to 3 ('this stops me from doing a lot of things or wastes a lot of my time'). Items contain categories such as persistent thoughts, checking, fear of dirt/dangerous objects, contamination, order and repetition.

2.3.1.5 Brown Attention Deficit Disorder Scales (Brown, 1996)

The Brown Attention Deficit Disorder Scales consist of 40 items, each rated on a scale of 0-3, according to the frequency of the behaviour. There are 5 individual scales: activation, attention, effort, affect and memory. A total score of less that 45 indicates that ADD is possible but not likely. A score of 45-59 indicates that ADD is probable but not certain and a score of 60-120 indicates that ADD is highly probable.

A total score of 50 is recommended as a clinical cut-off score to indicate a significant possibility that the person will meet diagnostic criteria for ADD.

2.3.1.6 Matson's Evaluation of Social Skills with Youngsters (MESSY) (Matson, 1990)

The MESSY is a self-rating survey of social skills. It consists of 62 items and each response is recorded on a scale of 1-5 ('not at all' to 'very much'). The items form 6 subscales: appropriateness, inappropriate assertiveness, overconfident, impulsive, jealous and miscellaneous and these can be summed to gain a total MESSY self-rating score.

2.3.2 Estimation of Intellectual Ability

2.3.2.1 Raven's Progressive Matrices (RPM) (Raven, 1960)

The Raven's Progressive Matrices consists of a series of visual pattern matching and analogy problems. It consists of 60 items, grouped into six sets. Each item contains a pattern with one part removed and a choice of six to eight pictured inserts to make the pattern complete. Only one of the pattern pieces contains the correct pattern and participants are required to point to the correct piece. The overall trend is for the items to go from easy to hard.

Retest reliability correlations run in the range of 0.7 to 0.9 and its validity as a measure of general ability has been consistently supported in correlational studies with other ability measures, with school-age children (Llabre, 1984).

2.3.2.2 Graded Word Reading Test (Schonell, 1976)

Participants are asked to read a page of words out aloud. The words become progressively more difficult. Younger children or those with difficulties reading start the test at the beginning. Better readers start at a later group of 10 words, although if any word is failed, the preceding group of 10 words is given until all 10 are read correctly. There are 100 words in total and the score is the total number of words reads correctly. This test is based on the assumption that familiar words will be pronounced correctly and that familiarity reflects vocabulary.

2.3.3 Executive Functioning

2.3.3.1 Stroop Test (Trennery, Crosson, DeBoe & Leber, 1989)

In the Stroop Test, there are two pages, each with 112 words printed on them. The words are the names of colours (blue, green, red and tan), but each word is printed in a colour that is incongruent with the word itself (e.g. the word 'blue' is printed in green ink). In the first part, the participant is instructed to read aloud the colour-words from the first page. In the second part, the participant is instructed to read aloud the colour of the ink of each word from the second page. On both trials, they are asked to read the words as quickly as possible and they are allowed 120 seconds

to respond before the task is terminated. Scores are calculated by summing the number of correct responses of items completed, minus the incorrect responses. The Stroop Test has satisfactory reliability (Spreen & Strauss, 1991).

2.3.3.2 Hayling Test (Burgess & Shallice, 1997)

In the Hayling Test, the examiner reads aloud a set of sentences, which all have the last word missing from them. In Section A, the participant is instructed to listen to each sentence and when the examiner has finished reading it, give the examiner a word that they think could fit at the end of the sentence. However, in Section B, the participant is instructed to give the examiner a word that is unrelated to the sentence in every way. In both sections, participants are told to respond as quickly as possible.

The response latencies on Section A provide a measure of response initiation speed. On Section B, participants who perform well are often able to develop a strategy to help them to inhibit responses, e.g. looking round the room and prepare answers beforehand, such as 'pencil', 'picture'. Participants who have difficulty on Section B may be slow to respond or impulsive and make errors by finishing the sentence with the appropriate word or a word that is semantically linked. Reliability estimates for an impaired group range from 0.72 to 0.93 (Burgess & Shallice, 1997).

2.3.3.3 Rule Shift Test (Wilson, Alderman, Burgess, Emslie & Evans, 1996)

During this test, the participant is shown a booklet of 21 playing cards. The cards are turned over one at a time and the participant is instructed to say 'yes' or 'no' according to a rule which they have in front of them, responding as quickly and accurately as they can. The first rule placed in front of the participant is, 'Say yes to red, no to black'. After this trial is completed, a second rule is placed in front of the participant. This is, 'Say yes if the card is the same colour as the last one, otherwise say no'. Both trials are timed and responses are recorded. This test measures the ability to respond correctly to a rule and to shift from one rule to another, without making perseverative errors.

2.3.3.4 Six Elements Test (Wilson, Alderman, Burgess, Emslie & Evans, 1996)

This test involves carrying out three types of task: dictation, picture-naming and arithmetic. Each of the three tasks is divided into two parts – Part A and Part B. Participants are told that during the following 10 minutes they have to complete at least some of each of the six individual parts. They are also told that they must not attempt one part of a particular task immediately after they have tried the other part and are given a timer to help organise their time. The final profile score is based on the number of tasks attempted, the number of rule breaks and length of time spent on any one of the six tasks. A good performance on this test relies on the ability to plan, organise and monitor behaviour.

2.3.3.5 Trail Making Test (Reitan, 1958)

The Trail Making Test is given in two parts. Each part is preceded by a sample so that the participant understands what they are being asked to do. In Part A, the participant is instructed to draw lines to connect twenty-five consecutively numbered circles on a sheet of paper. In Part B, the participant is presented with another sheet of paper, with twenty-five letters and numbers. They are instructed to alternate between numbers and letters and to connect them up consecutively, e.g. 1-A-2-B-3-C. They are asked to do this as quickly as they can and if they make a mistake, the examiner calls it to their attention and ask them to start from where the mistake occurred.

Common errors are of impulsivity, e.g. a jump from 12 to 13 on Part B, omitting the letter 'L', and perseveration, where the participant has difficulty shifting from number to letter. Reported reliability coefficients vary considerably, with most above 0.60 and most in the 0.80-0.90s (Spreen & Strauss, 1991).

2.3.3.6 Verbal Fluency Test (Thurstone & Thurstone, 1962)

Participants are asked to write down as many words beginning with the letter 'S' as they can in five minutes. There are certain rules they must follow, which include not giving names of people or places, numbers or days of the week, or words from the same root. This test requires participants to organise their thinking and participants who perform best of this test often develop a strategy to guide their search for words.

For example, one effective strategy is the use of the same initial consonant, e.g. 'sand', 'sack' and 'saddle'.

2.3.4 Explicit Memory

2.3.4.1 Story Recall Test (AMIPB) (Coughlan & Hollows, 1985)

In Story Recall, a short story is read to the participant and immediately after this, the participant is asked to recall as much of the story as they can remember. The story contains 28 ideas and the participant gains 2 points of credit for each idea recalled. The participant is told to try not to forget the story because they will be asked what they remember of it later on. After 30 minutes, the delayed recall trial is given. Answers are judged as correct if they do not alter the general meaning of the story or its details. Although this test was developed for adults, the test format and the nature of the story are appropriate for children.

2.3.4.2 Rey Auditory Verbal Learning Test (Rey, 1964; Taylor, 1959)

The Rey Auditory Verbal Learning Test consists of five presentations with recall of a 15-word list, one presentation of a second 15-word list and a sixth recall trial. In the first trial, the list of 15 words is read and the participant is asked to say back as many words as they can remember. The list is re-read for trials 2 to 5 and the participant is asked to say back as many words as they can remember including words that they have already given on previous trials. The second list of words is then read and the

participant is asked to recall them. Following this, the participant is asked to recall as many words from the first list as possible, without the words being read to them.

The first trial measures immediate recall and most studies have found a range of 6.3 to 7.8 for people under 70. The change in the number of words recalled from the first to the fifth trial shows the rate of learning and most studies indicate a range of 12 to 14 for the fifth trial. The second word list, like the first trial, measures immediate recall and typically generates scores in the same range. Test-retest reliability coefficients are in the 0.38 to 0.70 range (Snow, Tierney & Zorzitto, 1988).

2.3.4.3 Visual Reproduction Test (WMS-R) (Wechsler, 1987)

This is a test of memory for designs, in which the participant is shown four drawings, one at a time for 10 seconds. The drawing is then taken away and the participant has to draw it from memory. After a period of 30 minutes, there is a delayed trial. The same scoring criteria applies to both trials. This test is a test of visual recall memory and reliability coefficients range from 0.53 to 0.74 (Lezak, 1995).

2.3.5 Implicit Learning

2.3.5.1 Stem Completion Test

The Stem Completion Test is based on the protocol designed by Warrington and Weiskrantz (1974). During the study phase, participants listen to a tape and are

presented with a list of 40 low-frequency words, one at a time, and are asked to judge on a five-point scale how much they like each word. There are two parallel forms for this test and participants are allocated randomly to either version. After a 10 minute delay, participants carry out the priming task and are told that they will be carrying out a new task, in which they will be hearing sounds that are the beginnings of various words. For each sound, they should write down the first word that comes to mind, for example, the sound 'clo' could be the beginning of the words 'clover' or 'clothing'. Forty word stems are presented one at a time, allowing the participant 5 seconds to think of a word and write it down. Twenty of these word stems are the beginning of words that were presented earlier in the study phase and 20 are new distractor items. Learning is measured as the difference in the number of words given by participants that have been primed and words that are given which are the same frequency as the primed words, but the participants have not seen before.

This is followed by a recognition task, in which participants have to listen to the 20 words that were presented earlier in the study phase and were not used in the priming task. Each word is read in a male and female voice and participants have to mark on a form which voice (male or female) originally said the word.

2.3.5.2 Perceptual Priming Test

The Perceptual Priming Test follows a similar procedure to that used by Parkin and Streete (1988). To begin with, participants are shown 24 pictures (4 pictures from 6 different categories) for 3 seconds each and asked to look at each of the pictures

carefully. After a short delay, participants are given the priming task. They are told that they will be shown a degraded picture and they have to say what it is as quickly as they can. If they are incorrect or unsure, the examiner turns over the page to the next picture. Each picture has 4 versions, which become more complete as the page is turned over and the final version is the complete form of the picture. The priming task consists of 24 pictures, of these 12 are from the original study items and 12 are new distracter items. The examiner records which version of the picture the participant named the picture correctly and response times. Learning is measured as the difference between the number of trials it takes the participants to correctly identify primed pictures and distractor pictures that have not been seen before.

Following this, a recognition trial is administered. Participants are shown 24 pictures, including the 12 original study items that were not used in the priming task and 12 new distracter items, and asked to decide as quickly as possible whether or not they had seen each picture in the original set.

2.3.5.3 Serial Reaction Time Test

The Serial Reaction Time Test is based on the protocol devised by Nissen & Bullemer (1987) to measure sequence learning. The task is carried out on a laptop computer and keypad and participants are given instructions on the screen. They are told that they will see five squares on the screen, with one located in the centre of the screen and the others located to the left and right, above and below the centre box. At times, four different letters will appear in the surrounding boxes, L in the left box, R

in the right box, U in the up box and D in the down box. When one of the letters comes up in its box on the screen, the participant has to decide which is the matching button on the keypad and press it as quickly as possible. After each press, the centre box lights up on the screen and they have to press the centre button in order to make the next letter appear. The centre button is equidistant from the other four buttons on the keypad. They are told to press the correct button as quickly as possible, but without making mistakes and to use one finger to make the presses throughout the entire experiment. They are then asked to press the centre key to start.

Participants complete 8 blocks of 120 trials and successive blocks are separated by a short 20-second break. Unknown to participants, at times the letters follow a 12-trial specific repeating sequence: U-L-D-U-D-R-L-U-R-D-L-R. The first two blocks contain a pseudo-random sequence, the following four blocks contain the 12-trial sequence, the seventh block contains a test sequence (R-U-L-R-D-U-R-L-D-R-U-D) and the final block contains the 12-trial sequence. Responses and response latencies are saved to files. Learning is measured as the reaction time difference between a block of trials that follows the repeating sequence and an adjacent control block that does not follow the sequence.

At the end of the 8th block, participants carry out a recall task to assess explicit knowledge of the sequence. They are first asked whether they noticed a sequence and when they thought it had occurred. They are then told that during the task the order of the letters had followed a set sequence and are asked to type in whatever they can

remember of the sequence. The centre square lights up between each press and the task ends after 90 trials.

2.3.5.4 Mirror Reading Test

A Mirror Reading test was devised on the basis of the procedure used by Squire and Cohen (1980). Participants are presented with words that have been mirror-reversed and are asked to read aloud what the words are, as fast as possible. All words are low-frequency nouns, between 5 and 8 letters. Before the test begins, a triad of words is presented as a practice session. The first trial consists of 20 triads of words. After a 30-minute delay, a second trial of words is administered, containing 10 triads from the first session and 10 new triads in random order. Any errors are recorded and if the participant is unable to read a word, this is given to them by the examiner after a period of 20 seconds. Learning is measured as the difference in the time taken to complete the two trials, due to words having been presented before.

Following this trial, participants are given a recognition trial. A list of 40 words is presented, containing 20 target item from the mirror reading test and 20 distracter items, matched to the target words for length and frequency. These words are not mirror-reversed. Participants are asked to mark the items they have seen before in either of the mirror reading trials.

2.3.6 Naming

2.3.6.1 Boston Naming Test (Kaplan, Goodglass & Weintraub, 1983)

The Boston Naming Test consists of 60 drawings of items, ranging in familiarity from 'bed' to 'yoke' or 'abacus'. When participants are unable to name a drawing, they are given a semantic clue and if they are still unable to give the correct name, they are given a phonetic clue. For example, for pelican, 'it's a bird', 'pe'.

This test was designed for the evaluation of naming deficits. It correlates well with other tests of verbal ability and split-half reliability tests give correlations of 0.84 and above, suggesting good reliability (Lezak, 1995).

2.3.7 Perceptual Ability

2.3.7.1 Incomplete Letters Test (VOSP) (Warrington & James, 1991)

Incomplete Letters consists of 20 large alphabet letters, one on each card, which have been randomly degraded so that only 30% of the original shape remains. The participant has to decide what each of the letters is.

2.3.7.2 Number Location Test (VOSP) (Warrington & James, 1991)

Number Location presents two squares, each on ten stimulus cards. One square is above the other with the numbers from 1 to 9 randomly spaced within it. One of the

numbers in the square corresponds with the position of a dot in the bottom square. The participant has to decide which number matches the position of the dot.

2.4 PROCEDURE

This study was part of a larger project given ethical approval by the Joint University College London and University College London Hospital's Committee on the Ethics of Human Research. Copies of the ethics approval can be found in the Appendices.

Four of the symptomatology measures (MOVES, Gaffney et al, 1994; LOI-CV, Berg, 1989; MESSY, Matson, 1990; CBCL, Achenbach, 1991) were sent to each participant before the appointment, so that they could be completed before the session. The other two symptomatology measures (the Yale Global Tic Severity Scale, Leckman et al 1988; the Brown Attention Deficit Disorder Scales, Brown, 1996) were administered by the examiner during the testing session.

Before each participant took part in the study, parental written consent was obtained. The written consent of the participants themselves was also obtained for those aged 16 and over. Copies of the consent forms and information sheets can also be found in the Appendices.

The tests were administered to participants individually either at UCL or at the participants' homes. All participants completed the battery of tests within one session and took between 3 and a half to 4 hours. This allowed for frequent breaks to minimise the effects of fatigue. The tests were administered in a fixed order, to ensure that any practice or fatigue effects were similar for all participants. This also ensured that delayed trials occurred after the correct amount of time.

3 RESULTS

3.1 ANALYSIS OF DATA

The computerised statistical package SPSS version 9 was used to analyse the data. A significance level of 5% was adopted throughout, except in the case of post-hoc tests, when a significance level of alpha divided by the number of tests carried out was used.

The data was inspected for skewness of distribution and the presence of outliers, as these could violate the assumptions of normality and linearity underlying parametric tests. The degree of skewness was calculated for each variable and compared against the standard error for skewness using the formula given by Tabachnick and Fidell (1996), in order to see whether it differed significantly from zero. The standard error for skewness is:

$$Ss = \sqrt{6/N} \quad = \sqrt{6/20} \quad = 0.55$$

where N is the number of cases. The probability of obtaining a skewness value of this size is:

$$z = \frac{S - 0}{Ss}$$

where S is the value for skewness. At the 1% level, a z-value in excess of ± 2.58 would lead to rejection of the assumption of normality. Entering this into the table,

$$S = \pm 2.58 \times Ss = \pm 2.58 \times 0.55 = \pm 1.41$$

Consequently a criterion of ± 1.41 was used as a cut-off point for normality for the present data set.

Positive skewness was detected in the TS group on the CBCL Internalising score and in the Control group on the LOI score. The scores on the implicit measure, the Perceptual Priming Test were positively skewed for the correct identification of pictures presented in the priming trial, those correctly identified in the recognition trial and the number of false positives responses in both the TS group and the Control group. The number of false positive responses in the Mirror Reading test were positively skewed in the TS group only. Positive skewness was also detected on a number of executive measures. The times taken on Section B and the overall number of errors on the Hayling test were positively skewed in both groups. The time taken to complete Part A of the Trail Making Test was positively skewed in the TS group, whilst the time taken to complete Part B was positively skewed in the Control group. The number of errors on Part A of the Trail Making Test and on the Verbal Fluency Test was positively skewed in both groups.

The scores on the recognition trial of the RAVLT were negatively skewed in the TS group. The times taken on Section B of the Hayling Test and the scores on the Six Elements subtasks were negatively skewed in the Control group. The scores on the VOSP Number Location were negatively skewed in both groups, whilst the scores on the VOSP Incomplete Letters were negatively skewed in the Control group only.

The data was also checked for outliers using a standardised score of ± 3.00, or 3 standard deviations from the mean, as the cut-off point for continuous variables (Tabachnick & Fidell, 1983). Standardised scores were calculated for each variable to identify any containing values outside these limits. The number of false positive responses on the Perceptual Priming Test and the median scores on the SRT Test contained outliers in both groups. In the TS group only, variables containing outliers included the CBCL Internalising score, the recognition trial of the Perceptual Priming Test, the number of false positive responses in the recognition trial of the Mirror Reading Test, the number of errors on the Verbal Fluency Test and the times on Part A of the Trail Making Test. The scores on the LOI-CV, the priming trial of the Perceptual Priming Test, times for Sections A and B on the Hayling Test, times and errors on Part B of the Trail Making Test and scores on the VOSP Incomplete Letters contained outliers in the Control group only.

Where appropriate, the skewed variables were transformed logarithmically. Transformation reduced the skewness to an acceptable degree and dealt with the outliers for the times on Parts A and B of the Trail Making Test, the times on Sections A and B of the Hayling Test, the score on the Stroop Test and the median scores for the SRT Test. Parametric tests were then performed on the log scores for these variables.

In the cases where normality could not be achieved, non-parametric tests were applied to the data. Variables analysed using non-parametric tests included the error

scores on the Hayling Test, Trail Making Test and the Verbal Fluency Test, the recognition task for the Perceptual Priming Test and the number of false positive responses on the recognition tasks for the RAVLT, Perceptual Priming Test and the Mirror Reading Test. The number of subtests on the Six Element Test and the scores on the VOSP Incomplete Letters and Number Location Tests were also analysed using non-parametric tests. The correlations between symptomatology measures and tests were carried out using the non-parametric Spearman's Rank test.

3.2 RESULTS FOR MEASURES OF SYMPTOMATOLOGY

As Table 3.1 indicates, t-tests showed significant differences between the TS group and the Control group on the measures of symptomatology: the MOVES ($t = 5.39$, $df = 38$, $p = .001$), the LOI-CV ($t = 2.54$, $df = 38$, $p = .015$), the Brown Attention Deficit Disorder Scales ($t = 3.82$, $df = 38$, $p = .001$), the CBCL Internalising Score ($t = 3.90$, $df = 38$, $p = .001$) and Externalising Score ($t = 2.28$, $df = 38$, $p = .028$), with the TS group scoring higher than the Control group on all measures.

Table 3-1 Mean scores for symptomatology measures.

	TS Group (n = 20)		*Control Group (n = 20)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
MOVES	14.60	(6.36)	5.30	(4.37)
LOI-CV	6.80	(7.48)	2.20	(3.09)
Brown ADHD Scales	48.15	(21.84)	25.80	(14.39)
CBCL				
Internalising Score	16.89	(9.85)	6.37	(6.43)
Externalising Score	14.26	(9.75)	8.00	(6.94)

3.3 RESULTS FOR EXECUTIVE FUNCTIONING

3.3.1 Hayling Test

ANOVA with one within-groups factor (task: Section A or Section B) and one between-groups factor (group: TS or Control) showed no significant group × task interaction on the Hayling Test ($F = .74$, $df = 1, 38$, $p = .396$). There was a significant effect of group ($F = 6.91$, $df = 1, 38$, $p = .012$) and the effect of task approached significance ($F = 3.57$, $df = 1, 38$, $p = .067$). To explore this further, t-tests were used, with an adjusted significance level of .025 (alpha divided by 2). They showed a significant difference between the TS group and the Control group on the time taken to complete Section A ($t = 1.52$, $df = 38$, $p = .013$) and a difference approaching significance on Section B ($t = 2.21$, $df = 38$, $p = .034$). Mean scores showed that the TS group tended to be slower than the Control group on both. Analysis of the error scores on the Hayling test was carried out using a Mann-Whitney test, which showed that the TS group made significantly more errors than the Control group ($z = 2.76$, $df = 38$, $p = .007$).

Table 3-2 Mean scores for the Hayling Test.

	TS Group (n = 20)		*Control Group (n = 20)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
Hayling Test				
Section A time (secs)	15.75	(12.16)	9.45	(7.59)
Section B time (secs)	30.85	(29.65)	17.15	(21.62)
Error Score	5.40	(5.49)	1.90	(3.16)

3.3.2 Rule Shift Test

A t-test showed that the difference between the TS group and the Control group approached significance on the Rule Shift Test ($t = 1.82$, $df = 38$, $p = .077$), with the TS group tending to perform worse than the Control group.

Table 3-3 Mean scores for the Rule Shift Test.

	TS Group (n = 20)		*Control Group (n = 20)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
Rule Shift Profile Score	3.15	(0.99)	3.60	(0.50)

3.3.3 Six Elements Test

A Mann-Whitney test showed a significant difference between groups on the number of subtasks carried out on the Six Elements test ($z = 2.71$, $df = 38$, $p = .011$), with the TS group performing worse than the Control group. A t-test also showed that the TS group performed significantly worse than the Control group on the Profile score of the Six Elements test ($t = 2.69$, $df = 38$, $p = .011$).

Table 3-4 Mean scores for the Six Elements Test.

	TS Group (n = 20)		*Control Group (n = 20)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
Six Elements test				
Number of subtests	4.10	(1.45)	5.30	(1.30)
Profile Score	2.25	(1.41)	3.30	(1.03)

3.3.4 Stroop Test

A t-test demonstrated a significant difference between groups on the Stroop Colour-Word Score (t = -2.39, df = 38, p = .022), with the TS group tending to perform worse than the Control group.

Table 3-5 Mean scores for the Stroop Test.

	TS Group (n = 20)		*Control Group (n = 20)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
Stroop Colour-Word Score	62.15	(21.33)	82.70	(26.17)

3.3.5 Trail Making Test

ANOVA with one within-groups factor (task: Part A or Part B) and one between-groups factor (group: TS or Control) showed no significant group × task interaction on the Trail Making Test (F = .01, df = 1, 38, p = .934). The effect of group approached significance (F = 4.04, df = 1, 38, p = .051) and there was a significant effect of task (F = 432.21, df = 1, 38, p = .001). To explore this further, t-tests were used, with an adjusted significance level of .025 (alpha divided by 2). They showed differences approaching significance between the groups on the time taken to complete Part A (t = 1.90, df = 38, p = .065) and Part B (t = 1.86, df = 38, p = .070). Mean scores showed that the TS group was slower than the Control group on both parts. A Mann-Whitney test showed no differences on the number of errors on Part A

(z = -1.60, df = 38, p = .111), but a significant difference on the number of errors on Part B (z = -1.97, df = 38, p = .049), with the TS group tending to make more errors.

Table 3-6 Mean scores for the Trail Making Test.

	TS Group (n = 20)		*Control Group (n = 20)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
Trail Making Test				
Part A time (secs)	36.83	(20.53)	27.61	(9.55)
Part B time (secs)	87.65	(37.05)	68.69	(27.49)
Part A Errors	.10	(.31)	.35	(.59)
Part B Errors	.80	(.83)	.45	(1.00)

3.3.6 Verbal Fluency Test

A t-test demonstrated a significant difference between groups in scores on the Verbal Fluency Test (t = 2.48, df = 38, p = .018) with the TS group tending to perform worse than the Control group. However, a Mann-Whitney test did not show any significant differences in error scores (z = 0.25, df = 38, p = .803).

Table 3-7 Mean scores for the Verbal Fluency Test.

	TS Group (n = 20)		*Control Group (n = 20)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
Verbal Fluency test	25.55	(9.19)	32.70	(9.02)
Errors	.80	(1.06)	1.05	(1.47)

3.4 RESULTS FOR EXPLICIT MEMORY

3.4.1 Story Recall Test

As indicated in Table 3.8, ANOVA with one within-groups factor (task: immediate or delayed) and one between-groups factor (group: TS or Control) showed no significant group × task interaction on the Story Recall Test ($F = .01$, $df = 1, 38$, $p = .966$). The effect of group was not significant ($F = .01$, $df = 1,38$, $p = .934$), but there was a significant effect of task ($F = 11.60$, $df = 1,38$, $p = .002$). As indicated in Table 3.8, mean scores showed better scores on the immediate rather than the delayed trial.

Table 3-8 Mean scores for the Story Recall Test.

	TS Group (n = 20)		*Control Group (n = 20)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
Story Recall Test				
Immediate	37.35	(9.13)	37.15	(8.86)
Delayed	35.40	(9.21)	35.15	(7.79)

3.4.2 Rey Auditory Verbal Learning Test

The TS group performed significantly worse than the Control group on the total learning score, over Trials 1 to 5, for the RAVLT ($t = 2.13$, $df = 38$, $p = .040$) and on Trial 6, which is a list recall trial following an interference trial ($t = 2.26$, $df = 38$, $p = .029$). A Mann-Whitney test also showed a significant difference between groups on the recognition task of the RAVLT, with the TS group performing significantly worse than the Control group on the number of items correctly recognised ($z = 2.19$,

df = 37, p = .029) and the number of false positive responses (z = 2.92, df = 37, p = .003).

Table 3-9 Mean scores for the RAVLT.

	TS Group (n = 20)		*Control Group (n = 20)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
RAVLT				
Total Score	61.20	(11.81)	67.95	(7.88)
Trial 6: Post Interference Recall	10.50	(3.47)	12.55	(2.09)
Recognition	20.11	(3.53)	22.40	(1.85)
False Positives	2.74	(2.13)	1.00	(1.49)

3.4.3 Visual Reproduction Test

ANOVA with one within-groups factor (task: immediate or delayed) and one between-groups factor (group: TS or Control) showed a significant group × task interaction on the Visual Reproduction Test (F = 5.20, df = 1, 38, p = .028). The effect of group was not significant (F = 1.89, df = 1,38, p = .177), but there was a significant effect of task (F = 18.24, df = 1,38, p = .001). To explore this further, t-tests were used, with an adjusted significance level of .025 (alpha divided by 2). While they did not demonstrate a significant difference between groups on the immediate trial of Visual Reproduction (t = -.11, df = 38, p = .911), the difference approached significance on the delayed trial (t = -2.12, df = 38, p = .041), with the TS group tending to perform worse than the Control group.

Table 3-10 Mean scores for the Visual Reproduction Test.

	TS Group (n = 20)		*Control Group (n = 20)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
Visual Reproduction Test				
Immediate	36.50	(5.18)	36.70	(6.04)
Delayed	30.25	(8.51)	34.80	(4.49)

3.5 RESULTS FOR IMPLICIT LEARNING

3.5.1 Stem Completion Test

ANOVA with one within-groups factor (task: primed or distractor words) and one between-groups factor (group: TS or Control) showed no significant group × task interaction on the Stem Completion Test ($F = .02$, $df = 1, 38$, $p = .890$). The effect of group was not significant ($F = 1.00$, $df = 1, 38$, $p = .323$), although the effect of task was significant ($F = 15.09$, $df = 1, 38$, $p = .001$). As indicated in Table 3.11, mean scores showed better scores on primed rather than distractor words. A t-test did not demonstrate a significant difference between groups on the recognition task ($t = 1.60$, $df = 18$, $p = .119$).

Table 3-11 Means scores for the Stem Completion Test.

	TS Group (n = 20)		*Control Group (n = 20)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
Stem Completion Test				
Primed words	3.05	(1.57)	2.80	(2.12)
Distractor words	1.70	(1.13)	1.35	(0.75)
Recognition task	11.65	(2.01)	12.75	(2.34)

3.5.2 Perceptual Priming Test

ANOVA with one within-groups factor (task: primed or distractor trials) and one between-groups factor (group: TS or Control) showed no significant group × task interaction on the Perceptual Priming task ($F = .52$, $df = 1, 38$, $p = .477$). Neither the effect of group ($F = .78$, $df = 1, 38$, $p = .782$), nor the effect of task was significant ($F = 2.59$, $df = 1, 38$, $p = .116$). A Mann-Whitney test did not demonstrate significant differences between the groups on the recognition task ($z = 1.53$, $df = 18$, $p = .125$) or the number of false positive responses on the recognition task of the Perceptual Priming Test ($z = 1.01$, $df = 18$, $p = .311$).

Table 3-12 Mean scores for the Perceptual Priming Test.

	TS Group (n = 20)		*Control Group (n = 20)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
Perceptual Priming Test				
Primed trials	29.80	(3.69)	29.10	(3.08)
Distractor trials	30.25	(3.37)	30.35	(3.05)
Recognition task	20.75	(2.97)	21.90	(1.77)
False Positives		(0.45)	0.25	(0.72)

3.5.3 Mirror Reading Test

ANOVA with one within-groups factor (task: Trial 1 or Trial 2) and one between-groups factor (group: TS or Control) showed a group × task interaction approaching significance on the Mirror Reading Test ($F = 3.03$, $df = 1, 38$, $p = .090$). The effect of group was not significant ($F = .01$, $df = 1, 38$, $p = .912$), but the effect of task was significant ($F = 87.05$, $df = 1, 38$, $p = .001$). Mean scores shown in Table 3.13 demonstrated that the TS group tended to be faster than the Control group on Trial 1, but by Trial 2 they tended to be slower. A Mann-Whitney test did not demonstrate significant differences between the groups on the number of error scores on Trial 1 ($z = .59$, $df = 38$, $p = .558$) or Trial 2 ($z = 1.21$, $df = 38$, $p = .227$). A t-test demonstrated a difference approaching significance between groups on the recognition task ($t = 1.85$, $df = 37$, $p = .073$), with the Control group tending to recognise more items than the TS group. However, a Mann-Whitney test did not demonstrate a significant difference between the groups on the number of false positive responses on the recognition task of the Mirror Reading Test ($z = -.02$, $df = 37$, $p = .988$).

Table 3-13 Mean scores for the Mirror Reading Test.

	TS Group (*n* = 20)		*Control Group* (*n* = 20)	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
Mirror Reading Test				
Time on Trial 1	442.80	(167.66)	476.22	(216.94)
Time on Trial 2	320.25	(107.83)	297.51	(125.12)
Errors on Trial 1	14.67	(15.26)	8.90	(8.09)
Errors on Trial 2	11.11	(14.27)	3.30	(3.45)
Recognition task	15.84	(3.24)	17.30	(1.38)
False Positives	1.42	(2.17)	1.10	(1.17)

3.5.4 Serial Reaction Time Test

ANOVA with one within-groups factor (task: pseudorandom Blocks 1 or 2) and one between-groups factor (group: TS or Control) showed no significant group × task interaction on the pseudorandom blocks of the SRT Test ($F = .01$ $df = 1, 38$, $p = .935$). The effect of group was not significant ($F = .11$, $df = 1, 38$, $p = .746$), but the effect of task was significant ($F = 43.68$, $df = 1, 38$, $p = .001$). Mean scores shown in Table 3.14 demonstrated that the TS group tended to be slower than the Control group on the first pseudorandom block, but by the second they tended to be faster.

ANOVA with one within-groups factor (task: sequence Blocks 3, 4, 5 or 6) and one between-groups factor (group: TS or Control) showed no significant group × task interaction on the sequence blocks of the SRT Test ($F = .30$, $df = 1, 38$, $p = .801$). The effect of group was not significant ($F = .03$, $df = 1, 38$, $p = .875$), but the effect

of task was significant ($F = 21.75$, $df = 1, 38$, $p = .001$). Mean scores showed that the TS group tended to be faster than the Control group across all four sequence blocks.

ANOVA with one within-groups factor (task: sequence Block 6 or test Block 7) and one between-groups factor (group: TS or Control) showed no significant group × task interaction on the SRT Test ($F = 2.20$, $df = 1, 38$, $p = .146$). The effect of group was not significant ($F = .16$, $df = 1, 38$, $p = .687$), but the effect of task was significant ($F = 8.51$, $df = 1, 38$, $p = .006$). Mean scores showed that the TS group tended to be faster than the Control group on the sequence block and the test block.

ANOVA with one within-groups factor (task: mean of sequence Blocks 6 and 8 or test Block 7) and one between-groups factor (group: TS or Control) also showed no significant group × task interaction on the SRT Test ($F = 2.28$, $df = 1, 38$, $p = .140$). The effect of group was not significant ($F = .20$, $df = 1, 38$, $p = .658$), but as before the effect of task was significant ($F = 15.70$, $df = 1, 38$, $p = .001$). Mean scores showed that the TS group tended to be faster than the Control group on the sequence blocks preceding and following the test block and on the test block itself.

On the recall task for the SRT Test, a t-test demonstrated a significant difference between groups on the number of correct presses of strings of three or more in the sequence ($t = 2.19$, $df = 37$, $p = .035$). Mean scores showed that the TS group tended to recall less strings of three or more than the Control group. However, t-tests did not

show a difference between the groups on presses of strings of four or more (t = 1.23, df = 37, p = .226), five or more (t = 1.23, df = 37, p = .225), six or more (t = .39, df = 37, p = .697), seven or more (t = .41, df = 37, p = .688) or eight or more (t = .12, df = 37, p = .907). A t-test also showed no significant difference between groups on the longest string of the sequence recalled (t = .113, df = 37, p = .911).

Table 3-14 Mean scores for the Serial Reaction Time Test.

	TS Group (n = 20)		*Control Group (n = 20)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
Serial Reaction Time Test				
Block 1. Pseudorandom	671.00	(177.70)	660.05	(209.00)
Block 2. Pseudorandom	589.25	(121.38)	590.80	(206.43)
Block 3. Sequence	562.80	(103.83)	601.15	(226.59)
Block 4. Sequence	543.70	(92.92)	559.40	(165.85)
Block 5. Sequence	518.30	(87.06)	530.35	(139.28)
Block 6. Sequence	505.40	(78.74)	524.90	(186.22)
Block 7. Test	516.10	(61.45)	559.05	(161.71)
Block 8. Sequence	490.60	(69.76)	510.30	(162.78)
Recall Task				
Strings of 3 or more	75.16	(14.77)	84.25	(10.98)
Strings of 4 or more	44.53	(16.72)	51.85	(20.16)
Strings of 5 or more	21.26	(19.15)	28.25	(16.16)
Strings of 6 or more	13.11	(16.41)	15.00	(13.72)
Strings of 7 or more	7.42	(12.14)	9.00	(12.21)
Strings of 8 or more	4.47	(6.65)	6.65	(1.53)
Longest String	6.79	(1.69)	6.85	(1.66)

3.6 RESULTS FOR NAMING

A t-test showed that there were no significant differences between groups on the Boston Naming Test (t = .69, df = 38, p = .496).

Table 3-15 Mean scores for the Boston Naming Test.

	TS Group (n = 20)		*Control Group (n = 20)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
Boston Naming Test	47.90	(6.18)	49.20	(5.76)

3.7 RESULTS FOR PERCEPTUAL ABILITY

A Mann-Whitney test showed no significant differences between groups on either the Incomplete Letters Test (z = .43, df = 38, p = .665) or the Number Location Test (z = 1.59, df = 38, p = .112) from the VOSP.

Table 3-16 Mean scores for measures of perceptual ability.

	TS Group (n = 20)		*Control Group (n = 20)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
VOSP				
Incomplete Letters Test	19.65	(0.49)	19.50	(0.76)
Number Location Test	9.00	(2.03)	9.85	(0.37)

3.8 RESULTS OF CORRELATIONS BETWEEN SYMPTOMS & MEASURES

Spearman's Rank correlations were carried out between measures of symptomatology and performance on tests that found significant differences between the TS group and the Control group. In the TS group, the MOVES total score correlated with the time on Section B of the Hayling Test ($r = -.498$, $p = .025$), with more symptoms associated with a faster time. The LOI-CV score correlated with the RAVLT Recognition task ($r = -.467$, $p = .044$) and the time on Section A of the Hayling Test ($r = .450$, $p = .046$), more obsessional symptoms associated with more items recognised on the RAVLT, but a slower time on the Hayling Test. The Brown Attention Deficit Disorder Scales total score correlated significantly with the Stroop Colour-Word score ($r = .607$, $p = .004$), with more symptoms of ADHD associated with a slower performance.

In the Control group, age correlated significantly with a number of measures, including the Graded Name Reading Test ($r = .503$, $p = .023$), RAVLT Trial 1($r = .456$, $p = .043$), SRT Block 1 ($r = -.516$, $p = .022$), SRT Block 2 ($r = -.538$, $p = .014$), SRT Block 3 ($r = -.495$, $p = .026$), SRT Block 5 ($r = -.501$, $p = .024$), SRT Block 6 ($r = -.514$, $p = .020$), SRT Block 7 ($r = -.573$, $p = .008$), SRT Block 8 ($r = -.585$, $p = .006$), Mirror Reading Trial 2 ($r = -.622$, $p = .003$) and the Mirror Reading Recognition task ($r = -.699$, $p = .001$). All measures, with the exception of the Mirror Reading Recognition task, found that older age was associated with a better performance.

3.9 THE CONTRIBUTION OF CO-MORBID CONDITIONS

In order to explore the contribution of co-morbid conditions to the results where significant differences between the two groups were found, the TS group was split into two subgroups. One group (n = 9) comprised of participants with a diagnosis of TS only, whilst the other group (n = 11) comprised of participants with a diagnosis of TS, who also met DSM-IV criteria for either OCD/ADHD or both. T-tests showed that these two groups were not significantly different on age (t = .78, df = 18, p = .446).

3.9.1 Results for Measures of Symptomatology

T-tests did not show significant differences between the TS-only and the TS-comorbid groups on the MOVES (t = .51, df = 18, p = .614) or the Yale Tic Severity Rating (t = .24, df = 18, p = 811). However, there were significant differences between groups on the LOI-CV (t = 2.53, df = 18, p = .021) and the Brown Attention Deficit Disorder Scales (t = 3.08, df = 18, p = .006), with the TS-comorbid group tending to perform worse on both measures. There was no significant difference between groups on the CBCL Internalising subscale (t = .24, df = 18, p = .816), but the difference between the groups on the CBCL Externalising subscale approached significance (t = 1.83, df = 18, p = .085), with the TS-comorbid group tending to perform worse than the TS-only group.

Table 3-17 Mean scores for TS-only and TS-comorbid groups on symptomatology measures.

	TS-only Group (n = 9)		*TS-comorbid Group (n = 11)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
MOVES	13.77	(7.55)	15.27	(5.50)
Yale Tic Severity Rating	31.00	(21.08)	28.82	(18.20)
LOI-CV	2.67	(3.46)	10.18	(8.29)
Brown ADHD Scales	34.33	(19.30)	59.45	(17.19)
CBCL				
Internalising Score	16.25	(7.52)	17.36	(11.60)
Externalising Score	9.75	(7.29)	17.55	(10.28)

3.9.2 Results for Executive Functioning

A t-test did not show any differences between the TS-only and the TS-comorbid groups on the time taken to complete Section A ($t = 1.54$, $df = 18$, $p = .140$) or Section B ($t = .34$, $df = 18$, $p = .739$) on the Hayling Test. A Mann-Whitney test also showed no significant difference on the error score ($z = 1.11$, $df = 18$, $p = .268$) on the Hayling Test.

A t-test did not show any differences between the TS-only and the TS-comorbid groups on the Rule Shift Test ($t = .60$, $df = 18$, $p = .554$).

A Mann-Whitney test showed no significant difference on the number of subtests completed on the Six Elements Test ($z = .27$, $df = 18$, $p = .784$) and a t-test did not

show any differences between the groups on the Profile score ($t = .08$, $df = 18$, $p = .939$).

A t-test showed a significant difference between the TS-only and the TS-comorbid groups on the Stroop Colour-Word score ($t = 2.86$, $df = 18$, $p = .010$). Mean scores showed that the TS-comorbid group tended to perform worse than the TS-pure group.

A t-test did not show any differences between the TS-only and the TS-comorbid groups on the time taken to complete Part A ($t = .12$, $df = 18$, $p = .909$) or Part B ($t = -1.01$, $df = 18$, $p = .325$) on the Trail Making Test. A Mann-Whitney test also showed no significant difference on the error scores on Part A ($z = 1.31$, $df = 18$, $p = .189$) or Part B ($z = 1.48$, $df = 18$, $p = .137$).

A t-test did not show any differences between the TS-only and the TS-comorbid groups on the Verbal Fluency Test ($t = .98$, $df = 18$, $p = .340$). However, a Mann-Whitney test showed a difference approaching significance on the error score ($z = 1.73$, $df = 18$, $p = .083$), with the TS-comorbid group tending to perform worse than the TS-pure group.

Table 3-18 Mean scores for TS-only and TS-comorbid groups on measures of executive functioning.

	TS-only Group (n = 9)		*TS-comorbid Group (n = 11)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
Hayling test				
Section A time (secs)	18.11	(8.72)	13.82	(14.53)
Section B time (secs)	31.33	(36.47)	30.45	(24.61)
Error Score	3.22	(2.05)	7.18	(6.79)
Rule Shift Profile Score	3.00	(1.12)	3.27	(0.90)
Six Elements test				
Number of subtests	4.00	(1.73)	4.18	(1.25)
Profile Score	2.22	(1.56)	2.27	(1.35)
Stroop Colour-Word Score	75.67	(23.79)	51.09	(10.62)
Trail Making test				
Part A time (secs)	38.41	(25.95)	35.54	(16.06)
Part B time (secs)	77.99	(35.99)	95.55	(37.67)
Part A Errors	0.00	(0.00)	0.18	(0.40)
Part B Errors	1.11	(0.93)	0.55	(0.69)
Verbal Fluency test	27.78	(10.57)	23.73	(7.94)
Errors	0.33	(0.50)	1.30	(1.25)

3.9.3 Results for Explicit Memory

A t-test showed that the difference between the TS-only and the TS-comorbid groups on the total RAVLT score approached significance ($t = 1.92$, $df = 18$, $p = .071$), with the TS-comorbid group tending to perform worse than the TS-only group. There were significant differences between the two groups on Trial 6 of the RAVLT (t =

2.79, df = 18, p = .012) and on the delayed trial of the Visual Reproduction Test (t = 2.83, df = 18, p = .011), with TS-morbid group continuing to perform worse than the TS-only group. However, a Mann-Whitney test did not demonstrate significant differences between the groups on the recognition task (z = 1.69, df = 17, p = .091) or the number of false positive responses on the recognition task of the RAVLT (z = 1.53, df = 17, p = .125).

Table 3-19 Mean scores for TS-only and TS-comorbid groups on measures of explicit memory.

	TS-only Group (n = 9)		*TS-comorbid Group (n = 11)*	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
RAVLT				
Total Score	66.44	(9.46)	56.91	(12.19)
Trial 6	12.56	(2.79)	8.82	(3.12)
Recognition	21.33	(2.83)	19.00	(3.86)
False Positives	1.89	(1.45)	3.50	(2.42)
Visual Reproduction Test				
Delayed	35.33	(7.04)	26.09	(7.46)

3.9.4 Results for Implicit Learning

On the Mirror Reading Test, a t-test did not show any differences between the TS-only and the TS-comorbid groups on the time taken to complete Trial 1 (t = .26, df = 18, p = .798), Trial 2 (t = -.58, df = 18, p = .567), or on the recognition task (t = 1.06, df = 18, p = .305).

Table 3-20 Mean scores for TS-only and TS-comorbid groups on the Mirror Reading Test.

	TS-only Group (*n* = 9)		*TS-comorbid Group* (*n* = 11)	
Measure	*Mean*	*S.D.*	*Mean*	*S.D.*
Mirror Reading				
Time on Trial 1	431.78	(199.17)	451.82	(146.54)
Time on Trial 2	304.44	(109.29)	333.18	(110.12)
Recognition task	16.67	(2.40)	15.10	(3.81)

3.10 SUMMARY OF MAIN FINDINGS

3.10.1 Executive Functioning

As expected, there were significant differences between the TS group and the Control group on the following tests of executive functioning:

- Hayling Test
- Six Elements Test
- Stroop Test
- Trail Making Test
- Verbal Fluency Test

The TS group tended to perform worse than the Control group on all of these tests. The difference on the remaining executive test, the Rule Shift Test, approached significance with the TS group again tending to perform worse than the Control group.

3.10.2 Explicit Memory

As expected, there were some differences between the TS group and the Control group on the following measures of explicit memory:

- RAVLT total learning score
- RAVLT list recall following an interference trial

- RAVLT recognition task
- RAVLT false positive responses on the recognition task
- Visual Reproduction delayed trial

However, there were no differences between groups on:

- Story Recall immediate and delayed trials
- Visual Reproduction immediate trial

3.10.3 Implicit Learning

Contrary to the hypothesis, there were no differences between the groups on the following measures of implicit learning:

- Stem Completion Test including a recognition task
- Perceptual Priming Test including a recognition task.
- Mirror Reading Test errors
- Mirror Reading Test false positive responses on the recognition task
- SRT Test
- SRT recall task: stings of four to eight or more
- SRT recall task: longest string recalled

The difference between the groups approached significance on:

- Mirror Reading Test
- Mirror Reading Test recognition trial

Mean scores showed that the TS group tended to be faster than the Control group on Trial 1, but slower on Trial 2 of the Mirror Reading Test and they tended to perform worse than the Control group on the recognition task.

There was a significant difference between the TS group and the Control group on the following measure:

- SRT recall task: strings of three or more

Mean scores showed that the TS group tended to recall less strings of three or more than the Control group. However, this is thought to reflect explicit learning.

3.10.4 Naming and Perceptual Ability

As expected, there were no significant differences between the TS group and Control group on the following tests of naming and perception:

- Boston Naming Test
- VOSP Incomplete Letters Test

- VOSP Number Location Test

3.10.5 Symptomatology

As expected, the TS group scored higher than the Control group on measures of TS symptoms, OCD, ADHD, and childhood problems:

- MOVES
- LOI–CV
- Brown Attention-Deficit Disorder Scales
- CBCL Internalising and Externalising scores

3.10.5.1 Relationship between Symptomatology and Tests

In the TS group, correlations were carried out between measures of symptomatology and performance on tests that were significantly different to the Control group.

- MOVES total score correlated with the time on Section B of the Hayling Test, with more symptoms associated with a faster time.
- LOI-CV score correlated with the RAVLT Recognition task, with more symptoms associated with more items recognised on the RAVLT.
- LOI-CV score correlated with the time on Section A of the Hayling Test, with more symptoms associated with a slower time on the Hayling Test.

- Brown Attention Deficit Disorder Scales total score correlated with the Stroop Colour-Word score, with more symptoms associated with a slower performance.

In the Control group, age correlated significantly with a number of measures, including:

- Graded Name Reading Test
- SRT Blocks 1, 2, 3, 5, 6, 7 & 8
- Mirror Reading Trial 2 and the Mirror Reading Recognition task

All measures, with the exception of the Mirror Reading Recognition task, found that older age was associated with a better performance.

3.10.6 The Contribution of Co-morbid Conditions

Where there were significant differences between the TS group and the Control group, the contribution of co-morbid conditions to the results was explored, by splitting the TS group into a TS-only and TS-comorbid group and examining differences between these two subgroups.

There were significant differences between the TS-pure and the TS-comorbid group on the Stroop Colour-Word score, the Verbal Fluency Test error score, RAVLT list

recall following an interference trial, Visual Reproduction delayed trial. The difference between the TS-only and the TS-comorbid groups approached significance on the RAVLT total score. Mean scores showed that the TS-comorbid group tended to perform worse than the TS-pure group across all measures. The differences on the remaining tests were not significant.

As expected, there were significant differences between the TS-only and the TS-comorbid groups on the symptomatology measures: LOI–CV, Brown Attention-Deficit Disorder Scales, CBCL Internalising and Externalising scores. Mean scores showed that the co-morbid group tended to have a greater number of symptoms or problems. However, there were no differences between the groups on the Yale Tic Severity Rating or age.

4 DISCUSSION

The main findings of this study were that the TS group performed worse than the Control group on tests of executive functioning and explicit memory. However, there were no differences on implicit tasks or on tests of naming and perception. These results will be discussed below.

4.1 PERFORMANCE ON TESTS OF EXECUTIVE FUNCTIONING

On the tests of executive functioning, the results were consistent with the hypothesis that the TS children would perform worse than control participants on executive measures. These tests involve skills in planning, organising and monitoring behaviour and this can involve the ability to produce a strategy to aid performance. For example, on the Hayling Test some individuals benefit from developing strategies to help them to inhibit responses, e.g. looking round the room and preparing answers beforehand. The Verbal Fluency Test also benefits from the use of strategy to guide the search for words, such as the use of the same initial consonant.

The results are consistent with previous studies demonstrating impairments in executive functioning in TS. Channon et al (1992) found impairments in sustaining attention and in focusing and shifting set between salient stimuli. Randolph et al (1993) found a relationship between more severe tic symptoms and a worse performance on measures of sustained attention and freedom from distractability. Baron-Cohen et al (1994) showed that children with TS performed worse on tasks

thought to reflect attentional problems and a general loss of inhibition. Georgiou et al (1995) demonstrated difficulties in the TS group in shifting the focus of attention and Shucard et al (1997) found the TS group showed slower reaction times than control participants on a continuous performance test, indicating either attentional dysfunction, motor dysfunction or both, with severity of complex tics a predictor of reaction time performance. The measures used in these studies are mainly concerned with attention. While the results of this study provide more evidence to add to this literature, they also suggest that TS is associated with impairment in not only attention, but other areas of executive functioning.

Some researchers have argued that children with TS suffer from a specific cognitive deficit, rather than general deficits on executive measures. Baron-Cohen et al (1994) suggested that children with TS suffer from a specific cognitive deficit in the 'Intention Editor', which they speculate is the mechanism that edits out one of several instructions that are competing in parallel. The TS children in their study were no different to control children on two hand movement tasks, opening and closing their hands and on Luria's sequential movement task, the 'fist-edge-palm' test. However, they performed worse on the Luria Hand Alternation Task and a Yes and No Game, where participants had to answer questions without using yes or no. Baron-Cohen et al argued that the first two tasks involved only serial intentions, whereas the second two tasks involved parallel intentions and maintained that the results could not be explained by a general loss of inhibition or attentional problems. However, any task that is not very simple may well involve parallel processing, suggesting that the complexity of the task may be a more important factor. It is

possible that rather than this being a specific cognitive deficit, the ability to inhibit one response over another parallel response reflects a more general cognitive impairment on more difficult tasks.

The findings of this study were that the TS group performed worse across all the executive measures. In so far as this study examined different aspects of executive ability, such as planning, self-monitoring, initiation, set-shifting and strategy generation, there is no evidence to support the position that TS is associated with selective impairments. However, it is important to note that while these tasks have face validity in relation to measuring different aspects of executive functioning, there is no general consensus as to how many different subprocesses truly underlie executive performance.

Over the years tests purporting to measure executive functioning have come under criticism for their lack of reliability in identifying the executive problems that patients may have in everyday life. Consequently, a patient may perform normally on formal testing and yet may be unable to carry out many daily living skills because of difficulties with volition, planning and carrying out tasks in an organised way. One of the major difficulties in examining executive functioning is the paradoxical need to structure a situation in which participants can show whether and how well they can make structure for themselves. Most cognitive tests allow the participant little room for discretionary behaviour and so the problem in examining executive functioning becomes how to transfer goal setting, structuring and decision-making

within a formal testing environment. In response to this problem, tests have recently been developed that are more ecologically valid and give the participant sufficient scope to think of and choose alternatives to demonstrate the main components of executive behaviour, such as the Six Elements Test from the Behavioural Assessment of Dysexecutive Syndrome. However, in this study the children with TS performed significantly worse not only on the more ecologically valid tests, such as the Six Elements Test, but also on the more abstract laboratory measures which do not always detect impairment. The fact that these difficulties were consistently shown in the tests provides compelling evidence for impairment in executive functioning in the TS group.

4.2 PERFORMANCE ON TESTS OF EXPLICIT MEMORY

The results on tests of explicit memory were broadly consistent with the hypothesis that the performance of TS children on these tasks would be worse than the Control group, because of the associated impairments in executive functioning and the role of the prefrontal cortex in explicit memory. The TS group performed worse on the RAVLT total learning score, list recall following an interference trial, recognition task and false positive responses on the recognition task and on the Visual Reproduction delayed trial, although there were no differences on the immediate trial of Visual Reproduction and both trials of Story Recall.

In explaining the findings of this study, the TS group tended to perform worse on the explicit memory tests that were more complex and sensitive to impairment. Both the

Story Recall Test and the immediate trial of the Visual Reproduction Test provided participants with a certain amount of structure and cueing, which is likely to have contributed to the lack of group differences. On Story Recall, participants are provided with material that links together semantically and this contribution of meaning is likely to aid retention and recall. Equally, on the immediate trial of the Visual Reproduction Test, the participants are shown the designs one by one and have to draw each design immediately after it is taken out of view. The delayed trial is more sensitive to impairment in that the participant has completed other tasks since being shown the designs and they are then required to produce all four drawings without any cues. This added complexity is likely to explain the significant findings.

The performance of the TS group on the Visual Reproduction Test was worse than the Control group on the delayed trial, but was no different to the Control group on the immediate trial. One possibility is that rapid forgetting occurs during the delay period, which then makes retrieval more difficult. However, a more likely explanation is that the delay makes retrieval more effortful. In addition, there is less structure to aid retrieval in the delayed trial. Neuroimaging studies suggest that retrieval involves activation in the prefrontal cortex and for the TS participants in this study the results may also be related to problems with executive functioning.

The TS group also performed worse than the Control group on the RAVLT recognition task and produced a greater number of false positive responses. This suggests that the differences on the RAVLT are not just retrieval problems alone, but

may also be related to difficulties in encoding the material. Recent functional imaging studies (e.g. Shallice et al, 1995) suggest that the encoding of verbal material involves activation in the left prefrontal cortex. The design of the RAVLT involves multiple presentations of the same material, suggesting that after the initial presentation the material is processed semantically, with participants establishing and maintaining new semantic linkages in the context of already established linkages. Dolan and Fletcher (1997) found that this type of encoding involves prefrontal activation, rather than hippocampal activation. Therefore, the difficulties experienced by the TS group on this test may well be related to problems with executive functioning.

Jacoby's (1991) process-dissociation model distinguishes between habit, which is automatic responding, and recollection, which is the consciously controlled use of memory. This distinction is similar to the one made between implicit and explicit learning. Hay and Jacoby (1996) argue that if habit produces the same response as recollection, it facilitates performance by leading to a correct response. Errors in performance occur when habit and recollection are opposed and failures in recollection lead to the habit response. These errors are more likely to take place when people are required to respond rapidly and respond on the basis of habit rather than recollection. They argue that memory difficulties often arise at the level of elaborative encoding rather than retrieval and result from a failure to recollect an event when speeded responding is required.

The results of this study suggest that the TS group was significantly disadvantaged in recollection, but tests measuring habit were not affected. These findings are consistent with the idea that the TS group had difficulty expanding on contextual information to enhance recollection. A possible explanation is that executive impairments mean that the TS group had difficulty in using strategies, such as elaborative encoding, to increase the chances of successful recollection.

Whilst there is a lack of literature on TS and performance on explicit memory tasks, the results on these measures are broadly consistent with Stebbins et al's (1995) findings that the TS group performed worse than control participants on a word list recall task, but there were no differences on a less sensitive recognition task or on a test of immediate memory span. The lack of difference between groups on the Story Recall Test in this study is consistent with Bornstein's (1991a) finding that there were no group differences on another story recall test, the Logical Memory Test from the WMS-R. However, Bornstein also administered the Visual Reproduction Test in his study and in contrast to this study, failed to find group differences on the delayed trial. There are differences between Bornstein's study and the current study although it is not clear which account for the conflicting findings. Participants in his study were adults rather than children, and while they all had a formal diagnosis of TS, they were recruited through the TS Association. Although co-morbidity for OCD was taken into account, there are no details about other co-morbid conditions, such as ADHD. Consequently, the difference in findings may be due to the age of participants, recruitment methods, differing comorbidity or another unknown factor.

4.3 PERFORMANCE ON TESTS OF IMPLICIT LEARNING

The results on the implicit learning tasks did not support the hypothesis that the TS group would perform significantly worse on implicit tasks involving skill learning and priming. There were no significant differences between the TS group and the Control group on any of the priming or skill learning measures, although the Mirror Reading score approached significance. In terms of associated recognition or recall measures, the TS group performed worse than the Control group on the Mirror Reading recognition score and one of the recall measures for the SRT Test. However, impairments on both of these are likely to be associated with explicit memory deficits, rather than implicit memory itself.

There is a lack of literature studying TS and implicit learning, which is perhaps surprising given that TS is a habit disorder. The only study to date that has examined the contribution of TS to performance on a test of implicit learning is that of Stebbins et al (1995), using a motor skill learning task, Rotary Pursuit. They controlled for motor tic interference by equating for baseline performance, but still found that adults with TS performed worse than the Control group. This research was carried out with 13 unmedicated males over the age of 18, with a diagnosis of TS, no co-morbid ADHD and a mean score in the mild range on the LOI. Consequently, the difference in findings may be due to the choice of measures, age of participants, medication effects, differing comorbidity or another unknown factor.

The results on the implicit tests did not demonstrate any dissociation between the different types of implicit learning: priming and motor skill learning. PET studies suggest that tests of priming involve frontal activation (e.g. Squire, Ojemann, Miezin, Petersen, Videen & Raichle, 1992; Keane, Gabrieli, Fennema, Growdon & Corkin, 1991), whereas skill learning is thought to involve striatal activation (e.g. Mishkin, Malamut & Bachevalier, 1984).

Specific pathology appears to be important in understanding the dissociations between different forms of implicit learning in disorders involving different areas of the brain. Typically, patients with Alzheimer's disease are impaired on word stem completion tasks. Alzheimer's disease is thought to affect many neocortical areas and it has been suggested that these difficulties in word priming can be attributed to damage in posterior association areas, which are thought to store lexical and semantic representations (Shimamura, Salmon, Squire & Butters, 1987). In contrast, patients with Parkinson's disease and Huntingdon's disease show little motor skill learning, but intact lexical and pictorial priming (e.g. Jackson et al, 1995). Both Parkinson's disease and Huntington's disease are associated with striatal abnormalities: Parkinson's disease is associated with severe neuronal loss in the substantia nigra, whereas Huntington's disease is associated with lesions in the striatum, particularly in the caudate nucleus (Lezak, 1995).

Given that TS has been linked to fronto-striatal impairment, we may have expected to see impaired priming and skill learning. However, there were no significant

difference between the TS group and the Control group on either priming or skill learning. It is possible that the abnormalities in the fronto-striatal system in TS are insufficient to produce an impaired performance in implicit tasks or they are not localised to the specific areas involved in implicit learning. Although Parkinson's disease and Huntingdon's disease are not associated with specific frontal pathology, it is perhaps surprising that they do not show any impairments on implicit tasks involving frontal activation, given the rich connections between the prefrontal cortex and striatum. Again, it may be that priming is localised to a specific area of the prefrontal cortex that is not involved in these conditions or that pre-frontal involvement in these conditions is insufficient to lead to an impaired performance on these tasks.

More generally, one of the problems with implicit tests is that it is not always clear whether particular tests are 'pure' implicit tests or whether they also involve explicit learning. Shanks and St. John (1994) argue that it is difficult to make comparisons between patient groups and control groups because control groups can use both implicit and explicit learning even when the test is designed to measure implicit learning. They also point out that researchers have not yet agreed upon the methods through which explicit knowledge can be measured and that there are difficulties disentangling the involvement of other related concepts of attention and awareness. Despite these methodological problems, the lack of significant findings was consistently found across the four implicit measures and so at this stage, the conclusion must be that the TS group are not impaired in implicit learning. This may have implications for habit-learning (see Section 4.8 on clinical implications).

Whilst most of the implicit measures demonstrated the expected priming or skill learning effects, where prior exposure to the stimulus facilitates the response, the Perceptual Priming Test did not show significant priming effects. There were little differences between the responses for the pictures that that been shown before (primed) and those that were new (distracters) in the Control group and this clearly compromises the validity of the test.

4.4 PERFORMANCE ON TESTS OF NAMING AND PERCEPTION

The lack of significant differences between the TS and Control groups on measures of naming and perception was consistent with the hypothesis that the groups would not differ on measures thought not to be dependent on the fronto-striatal system. One alternative potential explanation for this is that these tasks were less complex than the tasks that demonstrated significant differences between the groups, such as measures of executive functioning or explicit memory. However, some of the executive measures, such as the Rule Shift Test and the Trail Making Test are not thought to be complex tests and yet they still discriminated between the groups. Also, the scores of the participants did not demonstrate ceiling effects on the naming and perceptual tests. Therefore it appears more likely that these tests did not show significant differences between the groups because they are thought not to be dependent on the fronto-striatal regions, which are implicated in TS.

4.5 SYMPTOMATOLOGY

The finding that the TS group had greater co-morbidity than the Control group was consistent with the literature that suggests that it can present with a wide range of symptoms and co-morbid conditions including OCD, ADHD and other difficulties, such as conduct disorder, aggression, phobias and depression (Comings & Comings, 1987).

4.5.1 Relationship between Symptomatology and Measures

In the TS group, correlations were carried out between measures of symptomatology and performance on tests that were significantly different to the Control group. Two of the correlations were consistent with the idea that a greater number of symptoms would be associated with a worse performance on measures. The LOI-CV score correlated with the time on Section A of the Hayling Test, with more symptoms associated with a slower time on the Hayling Test, suggesting that more obsessional individuals slow down in order to make sure their performance is accurate. The Brown Attention Deficit Disorder Scales total score correlated with the Stroop Colour-Word score, with more symptoms associated with a slower performance. This suggests that a greater number of ADHD symptoms is associated with difficulty maintaining concentration and warding off the distractions of the words.

Unexpectedly, the other two significant correlations suggested that a greater number of symptoms was associated with a better performance on measures. The MOVES total score correlated with the time on Section B of the Hayling Test, with more

symptoms associated with a faster time. One possible explanation is that participants with higher scores were faster at the expense of accuracy, but the MOVES did not correlate with the Hayling error score, which suggests that this was not the case. The LOI-CV score correlated with the RAVLT Recognition task, with more symptoms associated with more items recognised on the RAVLT, which was unexpected since the co-morbid group performed worse than the group with TS alone on the RAVLT measures. One possible explanation for the correlation between the LOI-CV and the recognition task is that the more obsessional participants circled more items in total than the others. However, there was not a significant correlation on the number of false positive responses given, so this does not appear to be the case. It may just be that this is an example of greater obsessionality being associated with a more careful and rigorous approach.

The fact that the CBCL Internalising and Externalising subscores did not correlate significantly with any measures was unexpected. Evidence suggests that certain aspects of cognitive performance are adversely affected by emotional disorders because the amount of cognitive capacity available to process information is reduced due to task-irrelevant processing (Lezak, 1995). The lack of significant correlations between the measures and the CBCL subscores suggests that emotional difficulties cannot account for the performance on the tests.

Equally, the lack of correlations between the Yale Tic Severity Scale and the measures could be seen as evidence that tic severity did not affect performance

adversely. This is not consistent with other studies which have found a relationship between tic severity and performance on tests of neuropsychological tests, including spatial, motor and graphic skills (Bornstein, 1990; Bornstein et al, 1991, Randolph et al, 1993) and attention (Randolph et al, 1993; Shucard et al, 1997). One possible explanation is that Bornstein (1990) and Bornstein et al's (1991) studies found correlations between complex tics and test performance, whereas this study did not differentiate between the type of tics in the analysis. However, Randolph et al (1993) and Shucard et al (1997) also investigated tic severity and still found a relationship with test performance. Both the Bornstein studies and Shucard et al's study used the Tourette's Syndrome Global Scale (Harcherik, Leckman, Detlor & Cohen, 1984) and the difference in measure could account for the difference in findings. Finally, Randolph et al's (1993) study included ten twins who did not meet criteria for TS and this may also have contributed towards the differing results.

Researchers have suggested that tic severity may be related to a poorer performance on tests because the tics themselves could reduce the amount of cognitive resources available to process information. Alternatively, the tics, the attempt to suppress them or distracting thoughts associated with them may distract attention away from the task and disrupt the individual's performance. One possible explanation for the lack of correlations between tic severity and test performance is that during testing participants were able to suppress their tics or that they experienced less tics because of the effect of concentration. However, a number of tics in participants were evident during testing and so while this could be the case to some extent, it does not explain the whole picture. If tics are seen as habits, it may be that individuals were not aware

of them and consequently they did not reduce the amount of cognitive resources available to process test-related information.

Performance on a number of tasks did show some relationship with age in the Control group. This suggested a developmental contribution to test performance, with older children performing better than younger children over most of the measures. Older children performed better on the Graded Naming test, which is a test of intellectual ability and on the implicit measures, the SRT test and the second trial of the Mirror Reading Test. These correlations were related to response time not accuracy, suggesting that speed is the important variable rather than implicit learning itself. This is consistent with the literature that suggests implicit learning develops very early in life and is relatively insensitive to age (Graf, 1990). The lack of significant correlations between the measures and age in the TS group suggests that age did not play an important role in determining their performance on tests and that other factors associated with TS were of greater importance.

4.6 CONTRIBUTION OF CO-MORBID CONDITIONS

Where there were significant differences between the TS group and the Control group, the contribution of OCD and ADHD to the results was explored. However, it is important to point out that the small participant samples and the resulting low statistical power, in addition to the exploratory nature of this analysis does limit the generalisability of these findings.

The TS group was split into two subgroups: those with a diagnosis of TS only and those with additional diagnoses of OCD, ADHD or the two together. In accordance with this, there were significant differences between these two groups on the measures of OCD and ADHD, with the co-morbid group scoring higher than the TS only group on both.

On the tests of executive functioning, there were no significant differences between the TS-pure group and the TS-comorbid group on four of the six tests, although the co-morbid group performed significantly worse on two executive measures, the Stroop Colour-Word score and the Verbal Fluency error score. This suggests that on many of the measures it is the TS symptomatology itself that accounts for the differences between the TS group and the Control group, rather than the contribution of OCD and ADHD. However, there are still some executive measures on which the co-morbid conditions of OCD, ADHD or the two together are associated with these differences.

The lack of significant findings of four of the tests is consistent with other studies that have not found OCD or ADHD to be significant contributing factors. Channon, Flynn and Robertson (1992) did not find a relationship between obsessional symptoms and performance on tests of attention. In Randolph et al's (1993) study of monozygotic twins, there was no relationship between ADHD severity and performance on attentional measures. Yeates and Bornstein (1994) found no differences between children with TS with and without ADHD on the WCST. De

Groot, Yeates, Baker & Bornstein (1997) found that although there were trends towards impairment, the TS/ADHD group was not significantly more impaired on any measure of executive function than the TS or TS/OC symptoms groups.

However, a number of studies have found that both OCD and ADHD emerged as contributors to impairments in tests of executive function in TS. Studies have found co-morbid obsessive compulsive symptoms to be associated with poorer performances on the Wisconsin Card Sort Test (Bornstein, 1991b), while co-morbid ADHD is associated with worse performances on the Rey Osterrieth Complex Figure (Harris et al, 1995) and measures thought to reflect specific elements of attention, especially encoding, sustaining and focusing (Yeates & Bornstein, 1994; Silverstein et al, 1995). De Groot et al (1997) found that the combination of TS, obsessive compulsive symptoms and ADHD was associated with greater impairments on executive tasks than TS on its own or with one co-morbid condition. Studies on OCD and ADHD, without the presence of TS, also suggest that both conditions are associated with impaired performances on executive measures (e.g. Aronowitz et al, 1994; Head et al, 1989; Denkla, 1989; Pennington, 1991).

Consequently, the conclusion at this stage, based on the initial findings of this study and the existing literature, can only be that TS symptomatology does appear to be associated with executive difficulties. OCD, ADHD or the combination of both of them may contribute to performance on executive tests in more specific ways, but the relationship is not clear.

The results on the explicit memory measures were more consistent, with the co-morbid group performing significantly worse than the TS only group on both the RAVLT and the delayed trial of the Visual Reproduction Test. This suggests that OCD, ADHD or the two together are associated with the differences on these tasks. Earlier, it was suggested that these explicit tasks reflect executive difficulties. There is no literature on the contribution of OCD and ADHD to explicit memory in TS with which to compare this finding. However, both OCD and ADHD are associated with memory impairment (e.g. Boone et al, 1991; Tallis et al, 1998) as well as impairment on executive measures, as mentioned previously.

The only implicit measure that approached significance in the TS and Control groups was the Mirror Reading Test and so this was the only measure that the TS pure group and the TS co-morbid groups were compared on. There was no difference in the performance of these two groups, which suggests that OCD and ADHD are not associated with this finding. There are no studies on implicit learning and ADHD and the one study by Foa et al (1997) using priming with an OCD group suggested normal priming, which is consistent with this result.

Future research with a larger sample is required in order to be clearer about the contribution of co-morbid conditions. At this stage, the significant findings on the two executive measures and the explicit memory measures indicate that children with other co-morbid conditions tended to perform worse than those with only TS, but it is

impossible to be clear about which conditions are associated with the findings. In order to investigate this further, future research is needed with large enough samples to examine the relative contributions of ADHD and OCD, requiring a group of children with TS and OCD, a group with TS and ADHD and a group with TS, ADHD and OCD.

4.7 LIMITATIONS OF THE STUDY

The results obtained in this study must be viewed as preliminary due to the relatively small sample sizes. Replication with larger samples would be important in helping to validate these findings and ensure that any of the significant findings were not due to a Type I error since no attempt was made to control for the multiple statistical analyses in this study. The small participant samples and the resulting low statistical power, in addition to the exploratory nature of the study and the use of non-parametric tests, does limit the generalisability of the findings. However, this reflects the difficulty in obtaining patient samples and the consistent nature of the results suggests that the findings are meaningful.

Another limitation may be the reliance on a clinic sample, which could reduce generalisability to the wider population of TS, many of whom are not known to services. Recent research suggests that there are differences in these populations, in terms of symptomatology and co-morbidity (Mason et al, 1998). However, an informed decision was taken to recruit through clinics in order to study the children

that represent the more extreme end of the spectrum, to increase the chance of identifying their difficulties clearly.

An additional limitation on generalisability may be that because the patients in the TS group were either on medication or judged not to need medication, it is possible that performance differences may not have been detected that would exist in an unmedicated, unsymptomatic sample. However, previous findings indicate that medicated TS patients do not differ from unmedicated patients with similar degrees of TS symptoms on neuropsychological tests (Bornstein & Yang, 1991; Golden, 1984). Nevertheless, the possibility remains that performance on these tests could be attributable to medication and further studies will be necessary to investigate this possibility.

4.8 CLINICAL IMPLICATIONS OF THE FINDINGS

The mechanism by which habits are thought to be acquired is implicit learning and these findings suggest that the habit-learning system is intact. This is contrary to the hypothesis that suggested that because TS is associated with striatal dysfunction, this would lead to some deficits in implicit or habit learning. However, the findings from this study are consistent with Azrin and Nunn's (1973) suggestion that TS could be considered as a habit, in that tics are repetitive behaviours that serve no adaptive function. They suggested that tics may originally start as a normal reaction, due to injury, trauma or an infrequent normal behaviour that has increased in frequency and altered in form. They become classified as habits when they persist and are carried

out at an unusually high frequency and in an unusual form. Normally habits would be inhibited by personal or social awareness because of their peculiarity or inconvenience, but they blend into normal movements so they become part of a response chain that assumes a compulsive character.

Given that the findings from the implicit learning tests in this study suggest that the habit-learning system is actually intact, it may be that executive problems account for the persistence of tics. Impaired executive functioning may mean that once the tics are acquired they cannot properly be extinguished because the ability to inhibit responses is impaired. Alternatively, the habits may not be normally acquired due to the impairments in executive functioning and this may lead to difficulties in extinguishing them.

The performance of the TS group on the implicit measures lends validity to Azrin and Peterson's (1990) behavioural clinical intervention for TS, called habit reversal. This involves the isometric tensing of muscles to prevent tics, with awareness training as an adjunct so that patients become aware of every occurrence of tics so that they are able to interrupt each movement. This treatment has been evaluated in several studies of TS and tics have found to be reduced by 55-100% (e.g. Azrin & Peterson, 1998/1990; Bullen & Hemsley, 1983; Finney, Rapoff, Hall & Christopherson, 1983; Franco, 1981, Peterson & Azrin, 1991; Zikis, 1983). It also appears to have led to a greater reduction in tics than self-monitoring, relaxation or massed negative practice (Peterson & Azrin, 1991; Azrin & Nunn, 1973).

The performance of the children with TS on the measures of executive functioning and explicit memory suggest that they may well experience difficulties in planning, organising themselves and monitoring their behaviour and this is likely to have an impact on both life at home and at school. This is consistent with research suggesting that many children with TS do under-perform at school (Robertson & Baron-Cohen, 1998). Consequently, these findings could provide the basis for a number of strategies that could be implemented by families, teachers and other professionals to help children with TS perform better at school. For example, strategies to facilitate executive-type problems could include helping the child to solve problems, by looking at the problems they experience, helping them to look at the possible courses of action, the likely impact of these courses of action, choosing which one to take and reviewing the relative success or failure of the choice. Other interventions such as taking frequent breaks, making pieces of work short and achievable and sitting the child at the front of the room could help maintain their attention. The use of memory strategies, such as using a notebook to write down instructions and homework, could also help the child become more organised and better able to remember things.

4.9 CONCLUSIONS AND DIRECTIONS FOR FUTURE RESEARCH

While generalisations of the results of this research to the larger TS population may be limited, it is still possible to make a number of tentative conclusions. At this stage, the findings suggest that the TS group were impaired on tests of executive functioning and explicit memory, which has an executive contribution. However, contrary to the hypothesis, there was little evidence of impairment on implicit tasks,

suggesting that habit-learning is intact. Therefore, it may be that executive problems may account for the persistence of tics, in that once the tics are acquired they cannot properly be extinguished because the ability to inhibit responses is impaired.

These findings suggest that there are a number of avenues that future research could take. To begin with, it would be useful to recruit a larger TS sample in order to be clearer about the contribution of co-morbid conditions. This requires large enough groups of children with TS and OCD, TS and ADHD and TS, ADHD and OCD. A second fruitful area of research is the refinement of measures, such as tests of implicit learning in order to be clearer about the contribution of explicit learning to these tasks. Finally, there is plenty of scope for research to develop and evaluate clinical interventions with children such as habit-reversal or programmes aimed at targeting executive-type problems, including attention training, memory training and the development of organisation and planning skills.

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6 APPENDICES

Appendix I: Letter giving ethical approval

UCL
HOSPITALS

The University College London Hospitals

The Joint UCL/UCLH Committees on the Ethics of Human Research

Committee Alpha Chairman: Professor André McLean

Please address all correspondence to:
Mrs Iwona Nowicka
Research & Development Directorate
9th Floor, St Martin's House
140 Tottenham Court Road, LONDON W1P 9LN
Tel. 0171- 380 9579 Fax 0171-380 9937
e-mail: i.nowicka@academic.uclh.nthames.nhs.uk

Dr Shelly Channon
Subdepartment of Clinical Health Psychology
UCL
Gower Street

23 September 1998

Dear Dr Channon

Study No: **95/2953** *(Please quote in all correspondence)*
Title: **Memory and executive function in patients with focal brain dysfunction**

The proposal to extend your work to people under 18 seems entirely proper and there is no objections on the ethical grounds as long as one small alteration can be made in the information sheet for healthy controls. It should be made clear in the first sentence that they are being asked as normal healthy people before there is any mention of injury or illness which involves the brain. For instance, one might say '... solve problems. We are asking some normal children to take part in a study to compare with the nature and extent of difficulties...'

Yours sincerely

Professor André McLean
Chairman

Appendix II: Letter to parents/guardian of TS participants

Subdepartment of Clinical Health Psychology
University College London, Gower Street, London WC1E 6BT

Dr. Shelley Channon
Director of Project

Research Assistants: 0171-504-5929
Sarah Crawford
Cristina Cassina
Kian Vakili

UCL 0171-387-7050
Overseas code +44-171
Fax 0171-916-1989

(date)

Dear ,

Thank you very much for allowing us to contact you regarding volunteering to help with our research at Prof. Robertson's clinic. We are about to begin a study concerned with how children and adolescents with Tourette Syndrome learn and remember things. An information sheet giving more details about the research is enclosed.

If you are still interested in participating, could you fill out the enclosed Volunteer Recruitment sheet and we will then contact you in relation to arranging an appointment.

Thank you once again for your interest in the study. If you would like any further information then please do not hesitate to contact us.

Yours sincerely

Polly Pratt
Clinical Psychologist
In training

Dr. Shelley Channon
Senior Lecturer in Psychology, UCL
Head of Neuropsychology Services, C&I CHS NHS Trust

Appendix III: Letter to parents/guardian of Control participants

Subdepartment of Clinical Health Psychology
University College London, Gower Street, London WC1E 6BT

Dr. Shelley Channon
Director of Project

Research Assistants: 0207 679 5929
Jasmine Chin
Liz Sinclair

UCL 0171-387-7050
Fax 0171-916-1989

(date)

Dear,

Your son *** has expressed an interest in participating in some research that we are carrying out, with support from Stanborough School.

We have an interest in problems and difficulties young people encounter with learning, remembering and solving problems when they have suffered injury or illness which involved the brain. We are looking for some healthy young people to take part in a study to compare with the nature and extent of difficulties in memory and reasoning in those who have suffered brain injury or illness. This has relevance for everyday living, where memory and problem solving have an important role.

We are approaching you to see whether you would consider allowing *** to take part in this research. It involves one session, which will be carried out on a one-to-one basis and will involve some simple computer tasks, pen and paper tasks and questionnaires. We cannot predict exactly how long it will take because of individual variation in the ways that people work; most people take around three to three and a half hours. If you agree, we will visit you at home. We can arrange appointments for after school or weekends and *** will be paid £10 for participating.

If you are interested, could you fill in the reply slip below, giving your telephone number and return it to the school office. We will then contact you in relation to arranging an appointment.

Enclosed is an information sheet, telling you more about the study, and a consent form. You can sign the consent form now or wait until the appointment if you would like to ask any questions.

Yours sincerely

Polly Pratt
Research Worker to Dr. Shelley Channon

✂----------

Child's Name _____

Signature of Parent/Guardian _____

Name _____

Address _____

_____

Telephone Number _____

Please return this to the school office.

Appendix IV: Volunteer Recruitment Form for TS participants

Study on Children and Adolescents with Tourette Syndrome

VOLUNTEER RECRUITMENT FORM (AGES 6-17)

To be filled out by parent on behalf on child/adolescent

Parent's Name _____

Address _____

_____

Telephone Number _____

INFORMATION ABOUT YOUR SON/DAUGHTER WITH TOURETTE SYNDROME

Name _____

Male/Female _____

Date of Birth _____

Left/Right-Handed _____

Is English his/her first language? Yes / No **Is she/he fluent in English? Yes / No**

What type of school does she/he attend _____

Does she/he have any special schooling needs? If yes, please give details _____

_____

Has she/he gained any qualifications? If yes, please give details _____

_____

Has she/he ever had a serious accident? If yes, please give details _____

_____

Has she/he ever been unconscious? If yes, please give details _____

_____

Has she/he ever had a serious illness? If yes, please give details _____

_____

Is she/he currently taking any prescribed medication? If yes, please give details _____

_____

If old enough, does she/he drink any alcohol? If yes, how much do they drink a week? ____

_____

Has she/he ever been diagnosed as having dyslexia? _____

Has she/he ever been diagnosed as having Attention Deficit Hyperactivity Disorder? _____

_____

Has she/he ever been diagnosed as having Obsessive Compulsive disorder?

_____

Name of Consultant _____ Name of GP _____

Address _____ Address _____

_____ _____

_____ _____

Please return this form to Polly Pratt, Subdepartment of Clinical Health Psychology, UCL, Gower Street, London, WC1E 6BT.

Appendix V: Volunteer Recruitment Form for Control participants

Study on Children and Adolescents with Tourette Syndrome

VOLUNTEER RECRUITMENT FORM FOR CONTROL GROUP

(YOUNG PEOPLE AGED 8-17 WITHOUT TOURETTE SYNDROME)

To be filled out by parent on behalf on child/adolescent

Parent's Name _____

Address _____

_____

Telephone Number _____

INFORMATION ABOUT YOUR SON/DAUGHTER

Name _____

Male/Female _____

Date of Birth _____

Left/Right-Handed _____

Is English his/her first language? Yes / No **Is she/he fluent in English? Yes / No**

What type of school does she/he attend _____

Does she/he have any special schooling needs? If yes, please give details _____

_____

Has she/he gained any qualifications? If yes, please give details _____

_____

Has she/he ever had a serious accident? If yes, please give details _____

_____

Has she/he ever been unconscious? If yes, please give details _____

_____

Has she/he ever had a serious illness? If yes, please give details _____

_____

Is she/he currently taking any prescribed medication? If yes, please give details _____

_____

If old enough, does she/he drink any alcohol? If yes, how much do they drink a week? ____

_____

Has she/he ever been diagnosed as having dyslexia? _____

Has she/he ever been diagnosed as having Attention Deficit Hyperactivity Disorder? _____

_____

Has she/he ever been diagnosed as having Obsessive Compulsive disorder?

_____

Please return this form to Polly Pratt, Subdepartment of Clinical Health Psychology, UCL, Gower Street. London. WC1E 6BT.

HEALTH SCREENING INTERVIEW

Appendix VI: Health Screening questionnaire for Control participants

Name
Address _____

_____

_____

Telephone No. _____

Sex? **Male / Female** Date of Birth? _____ Right- or left-handed? _____

Language fluency

Is your first language English? **Yes/ No**
If not, how fluent are you in English?_____
If not, please tell me all the languages you speak_____

_____
What age did you start to learn each one?_____

_____

_____

Do you have difficulty understanding conversations because of your hearing? **Yes/ No**
Do you have trouble with your vision that prevents you from reading ordinary print, even with glasses on? **Yes/ No**
Have you ever been diagnosed as having dyslexia? **Yes/ No**
Do you have difficulty in using your fingers for fine movements, such as doing up buttons? **Yes/ No**
Do you have any physical disabilities? _____

_____

_____

_____

Educational and occupational history

What type of school did you attend? _____
Did you have any special schooling needs? _____
If Yes, please give details_____
Did you have a Statement of special educational needs?_____
What age did you leave school?_____
What qualifications did you obtain at school?_____

_____

_____
What qualifications, if any, did you obtain after leaving school?_____

_____

_____

_____
How long was the course of study?_____
Full-time or part-time?_____
What are the main types of work you have done (if any)?_____

_____

_____

_____
What is your main job now?_____

_____

_____
How long have you held this job?_____
Has your work changed as a result of your illness/injury?_____

_____

_____

Health history

Have you ever had a serious illness? **Yes/No**
If Yes, please give details_____

Have you ever had heart trouble? **Yes/No**_____
If Yes, please give details_____

Have you ever had a serious accident? **Yes/ No**
If Yes, please give details_____

Have you ever been unconscious? **Yes/ No**
If Yes, how many times have you been unconscious? _____
For how long each time? _____

Why? _____

How long was the gap between losing consciousness and your first memory?_____

How long was the gap between losing consciousness and beginning to remember everyday details normally?_____

Have you ever had an operation under general anaesthetic? **Yes/ No**
If Yes, please give details_____

Have you ever had to stay in hospital for any reason? **Yes/ No**
If Yes, please give details_____

Have you ever had:
Meningitis **Yes/ No**
Encephalitis **Yes/ No**
Diabetes **Yes/ No**
Tuberculosis (TB) **Yes/ No**
Epilepsy/seizures/fits **Yes/ No**
If Yes, please give details_____

Are you currently taking any prescribed medication? **Yes/ No**
If Yes, please give details _____

How much alcohol do you drink each week?_____
Do you take any recreational drugs?_____

Have you taken any in the past?_____

Have you ever received treatment for mental or emotional problems? **Yes/ No**
If Yes, please give details_____

Injury or illness affecting the brain

Name of your consultant_____ Name of your GP_____
Consultant's address _____ GP's address _____

Detailed description of injury/illness_____

When did the injury/illness occur?_____

At which hospital(s) were you treated? (Full name and address if possible)
Inpatient care _____

Outpatient care _____

To your knowledge, did you have: An MRI brain scan? Yes/No A CT brain scan ? Yes/No
If Yes, at which hospital? _____

When was the scan done?_____

Have you suffered any problems since, such as difficulties with memory, problem-solving or planning? If so please give details _____

Are there any other important details about your medical history that I have not asked you about?_____

Appendix VII: Parental/Guardian consent form for TS participants

Subdepartment of Clinical Health Psychology
University College London, Gower Street, London WC1E 6BT

Dr. Shelley Channon
Director of Project
0171-391-1786

Research Assistants: 0171-504-5929

UCL 0171-387-7050
Overseas code +44-171
Fax 0171-916-1989

CONSENT FORM

Memory and problem-solving study

Director of project: Dr. Shelley Channon

To be completed by the parent/guardian of.....

Delete as necessary:

Have you read the information sheet about this study? Yes/No

Have you had an opportunity to ask questions and discuss this study? Yes/No

Have you received satisfactory answers to all your questions? Yes/No

Have you received enough information about this study? Yes/No

Which researcher have you spoken to about this study? .....

Do you understand that your son/daughter is free to withdraw from thisstudy at any time, without giving a reason for withdrawing, and without affecting his/her future medical care? Yes/No

Do you agree to your son/daughter taking part in this study? Yes/No

Signature of parent/guardian .....
Name .....
Date .....
Address .....
.....
.....
.....

Signature of researcher .....
Name .....
Date .....

Appendix VIII: Information sheet for parents/guardian of TS participants

Subdepartment of Clinical Health Psychology
University College London, Gower Street, London WC1E 6BT

Dr. Shelley Channon
Director of Project
0171-391-1786

Research Assistants: 0171-504-5929

UCL 0171-387-7050
Overseas code +44-171
Fax 0171-916-1989

INFORMATION SHEET

Memory and problem-solving study

Your son/daughter is being invited to take part in a study concerned with the ways in which people learn, remember and solve problems. The study aims to examine the nature and extent of difficulties in memory and reasoning in people of different ages, and in those who have suffered injury or illness which involved the brain. This has relevance for everyday living where memory and problem-solving play an important role.

All proposals for research using human subjects are reviewed by an ethics committee before they can proceed. This proposal was reviewed by the Joint UCL/UCLH Committees on the Ethics of Human Research.

He/she will be given a series of psychological tests which measure aspects of learning, memory and problem-solving. These will be arranged to suit his/her convenience, and he/she will be able to take breaks if feeling tired. Because of the nature of the study, we cannot give you precise details of the tests, so that this does not influence the findings. A series of questions will also be asked concerned with the way he/she is feeling and any difficulties he/she has been having, and there is also a set of questionnaires. The study does not include any blood tests or other medical procedures.

You will be asked to sign a consent form, and any information you give will be treated in strict confidence. Your son/daughter does not have to take part in this study if he/she does not want to, or if you do not wish it. If he/she decides to take part he/she may withdraw at any time without giving a reason. The decision whether to take part or not will not affect his/her care and management in any way.

Appendix IX: Consent form for TS participants over 16

Subdepartment of Clinical Health Psychology
University College London, Gower Street, London WC1E 6BT

Dr. Shelley Channon
Director of Project
0171-391-1786

Research Assistants: 0171-504-5929

UCL 0171-387-7050
Overseas code +44-171
Fax 0171-916-1989

CONSENT FORM

Memory and problem-solving study

Director of project: Dr. Shelley Channon

To be completed by the volunteer:	**Delete as necessary:**
Have you read the information sheet about this study?	Yes/No
Have you had an opportunity to ask questions and discuss this study?	Yes/No
Have you received satisfactory answers to all your questions?	Yes/No
Have you received enough information about this study?	Yes/No
Which researcher have you spoken to about this study?	.....
Do you understand that you are free to withdraw from this study at any time, without giving a reason for withdrawing, and without affecting your future medical care?	Yes/No
Do you agree to take part in this study?	Yes/No

Signature of volunteer .....
Name .....
Date .....
Address .....
.....
.....
.....

Signature of researcher .....
Name .....
Date .....

Appendix X: Information sheet for TS participants over 16

Subdepartment of Clinical Health Psychology
University College London, Gower Street, London WC1E 6BT

Dr. Shelley Channon
Director of Project
0171-391-1786

Research Assistants: 0171-504-5929

UCL 0171-387-7050
Overseas code +44-171
Fax 0171-916-1989

INFORMATION SHEET

Memory and problem-solving study

You are being invited to take part in a study concerned with the ways in which people learn, remember and solve problems, The study aims to examine the nature and extent of difficulties in memory and reasoning in people of different ages, and in those who have suffered injury or illness which involved the brain.This has relevance for everyday living where memory and problem-solving play an important role.

All proposals for research using human subjects are reviewed by an ethics committee before they can proceed. This proposal was reviewed by the Joint UCL/UCLH Committees on the Ethics of Human Research.

You will be given a series of psychological tests which measure aspects of learning, memory and problem-solving. These will be arranged to suit your convenience, and you will be able to take breaks if you feel tired. Because of the nature of the study, we cannot give you precise details of the tests, so that this does not influence the findings. You will also be asked a series of questions concerned with the way you are feeling and any difficulties you have been having, and asked to fill out a set of questionnaires. The study does not include any blood tests or other medical procedures.

You will be asked to sign a consent form, and any information you give will be treated in strict confidence. You do not have to take part in this study if you do not want to. If you decide to take part you may withdraw at any time without giving a reason. Your decision whether to take part or not will not affect your care and management in any way.

Appendix XI: Parental/Guardian consent form for Control participants

Subdepartment of Clinical Health Psychology
University College London, Gower Street, London WC1E 6BT

Dr. Shelley Channon
Director of Project
0171-391-1786

Research Assistants: 0171-504-5929

UCL 0171-387-7050
Overseas code +44-171
Fax 0171-916-1989

CONSENT FORM

Memory and problem-solving study

Director of project: Dr. Shelley Channon

To be completed by the parent/guardian of .....

Delete as necessary:

Have you read the information sheet about this study? Yes/No

Have you had an opportunity to ask questions and discuss this study? Yes/No

Have you received satisfactory answers to all your questions? Yes/No

Have you received enough information about this study? Yes/No

Which researcher have you spoken to about this study? .....

Do you understand that your son/daughter is free to withdraw from this study at any time, and without giving a reason for withdrawing? Yes/No

Do you agree to your son/daughter taking part in this study? Yes/No

Signature of parent/guardian .....
Name .....
Date .....
Address .....
.....
.....
.....

Signature of researcher .....
Name .....
Date .....

Appendix XII: Information sheet for parents/guardian of Control participants

Subdepartment of Clinical Health Psychology
University College London, Gower Street, London WC1E 6BT

Dr. Shelley Channon
Director of Project
0171-391-1786

Research Assistants: 0171-504-5929

UCL 0171-387-7050
Overseas code +44-171
Fax 0171-916-1989

INFORMATION SHEET

Memory and problem-solving study

Your son/daughter is being invited to take part in a study concerned with the ways in which people learn, remember and solve problems. We are asking some healthy children and young people to take part in the study to compare with the nature and extent of difficulties in memory and reasoning in people of different ages, and in those who have suffered injury or illness which involved the brain. This has relevance for everyday living where memory and problem-solving play an important role.

All proposals for research using human subjects are reviewed by an ethics committee before they can proceed. This proposal was reviewed by the Joint UCL/UCLH Committees on the Ethics of Human Research.

He/she will be given a series of psychological tests which measure aspects of learning, memory and problem-solving. These will be arranged to suit his/her convenience, and he/she will be able to take breaks if feeling tired. Because of the nature of the study, we cannot give you precise details of the tests, so that this does not influence the findings. A series of questions will also be asked concerned with the way he/she is feeling and any difficulties he/she has been having, and there is also a set of questionnaires. The study does not include any blood tests or other medical procedures.

You will be asked to sign a consent form, and any information given will be treated in strict confidence. Your son/daughter does not have to take part in this study if he/she does not want to, or if you do not wish it. If he/she decides to take part he/she may withdraw at any time without giving a reason.

Appendix XIII: Consent form for control participants over 16

Subdepartment of Clinical Health Psychology
University College London, Gower Street, London WC1E 6BT

Dr. Shelley Channon
Director of Project
0171-391-1786

Research Assistants: 0171-504-5929

UCL 0171-387-7050
Overseas code +44-171
Fax 0171-916-1989

CONSENT FORM

Memory and problem-solving study

Director of project: Dr. Shelley Channon

To be completed by the volunteer:	**Delete as necessary:**
Have you read the information sheet about this study?	Yes/No
Have you had an opportunity to ask questions and discuss this study?	Yes/No
Have you received satisfactory answers to all your questions?	Yes/No
Have you received enough information about this study?	Yes/No
Which researcher have you spoken to about this study?	.....
Do you understand that you are free to withdraw from this study at any time, and without giving a reason for withdrawing?	Yes/No
Do you agree to take part in this study?	Yes/No

Signature of volunteer .....
Name .....
Date .....
Address .....
.....
.....
.....

Signature of researcher .....
Name .....
Date .....

Appendix XIV: Information sheet for Control participants over 16

Subdepartment of Clinical Health Psychology
University College London, Gower Street, London WC1E 6BT

Dr. Shelley Channon
Director of Project
0171-391-1786

Research Assistants: 0171-504-5929

UCL 0171-387-7050
Overseas code +44-171
Fax 0171-916-1989

INFORMATION SHEET

Memory and problem-solving study

You are being invited to take part in a study concerned with the ways in which people learn, remember and solve problems. We are asking some healthy people to take part in the study, to compare with the nature and extent of difficulties in memory and reasoning in people of different ages, and in those who have suffered injury or illness which involved the brain. This has relevance for everyday living where memory and problem-solving play an important role.

All proposals for research using human subjects are reviewed by an ethics committee before they can proceed. This proposal was reviewed by the Joint UCL/UCLH Committees on the Ethics of Human Research.

You will be given a series of psychological tests which measure aspects of learning, memory and problem-solving. These will be arranged to suit your convenience, and you will be able to take breaks if you feel tired. Because of the nature of the study, we cannot give you precise details of the tests, so that this does not influence the findings. You will also be asked a series of questions concerned with the way you are feeling and any difficulties you have been having, and asked to fill out a set of questionnaires. The study does not include any blood tests or other medical procedures.

You will be asked to sign a consent form, and any information you give will be treated in strict confidence. You do not have to take part in this study if you do not want to. If you decide to take part you may withdraw at any time without giving a reason.

Appendix XV: Copy of Yale Global Tic Severity Scale

The Yale Global Tic Severity Scale

A. Number: a) Motor Score: ☐ b) Phonic Score: ☐

0 None
1 Single tic
2 Multiple discrete tics (2-5)
3 Multiple discrete tics (more than 5)
4 Multiple discrete tics plus at least one orchestrated pattern of multiple simultaneous or sequential tics where it is difficult to distinguish discrete tics
5 Multiple discrete tics plus several (>2) orchestrated pattern of multiple simultaneous or sequential tics where it is difficult to distinguish discrete tics

B. Frequency: a) Motor Score: ☐ b) Phonic Score: ☐

0 None. No evidence of specific tic behaviours.
1 Rarely. Specific tic behaviours have been present during previous week. These behaviours occur infrequently, often not on a daily basis. If bouts of tics occur, they are brief and uncommon.
2 Occasionally. Specific tic behaviours are usually present on a daily basis, but there are long tic-free intervals during the day. Bouts of tics may occur on occasion and are not sustained for more than a few minutes at a time.
3 Frequently. Specific tic behaviours are present on a daily basis. Tic free intervals as long as 3 hours are not uncommon. Bouts of tics occur regularly but may be limited to a single setting.
4 Almost Always. Specific tic behaviours are present virtually every waking hour of every day, and periods of sustained tic behaviours occur regularly. Bouts of tics are common and are not limited to a single setting.
5 Always. Specific tic behaviours are present virtually all the time. Tic-free intervals are difficult to identify and do not last more than 5 to 10 minutes at most.

C. Intensity: a) Motor Score: ☐ b) Phonic Score: ☐

0 Absent
1 Minimal intensity, tics not visible or audible (based solely on patient's private experience) or tics are less forceful than comparable voluntary actions and are typically not noticed because of their intensity.

2 Mild intensity, tics are not more forceful than comparable voluntary actions or utterances and are typically not noticed because of their intensity.

3 Moderate intensity, tics are more forceful than comparable voluntary actions but are not outside the range of normal expression for comparable voluntary actions or utterances. They may call atention to the indivual because of their forceful character.

4 Marked intensity, tics are more forceful than comparable voluntary actions or utterances and typically have an "exaggerated" character. Such tics frequently call attention to the individual because of their forceful and exaggerated character.

5 Severe intensity, tics are extremely forceful and exaggerated in expression. These tics call attention to the individual and may result in risk of physical injury (accidental, provoked, or self-inflicted) because of their forceful expression.

D. Complexity: a) Motor Score: ☐ b) Phonic Score: ☐

0 None, if present, all tics are clearly "simple" (sudden, brief, purposeless) in character.

1 Borderline, some tics are not clearly "simple" in character.

2 Mild, some tics are clearly "complex" (purposive in appearance) and mimic brief "automatic" behaviours, that could be readily camouflaged, (e.g. grooming).

3 Moderate, some tics are more "complex" (more purposive and sustained in appearance) and may occur in orchestrated bouts that would be difficult to camouflage but could be rationalized or "explained" as normal behaviour or speech (e.g. picking, tapping).

4 Marked, some tics are very "complex" in character and tend to occur in sustained orchestrated bouts that would be difficult to camouflage and could not be easily rationalized as normal behaviour or speech because of their duration and/or their unusual, inappropriate, bizarre, or obscene character, (e.g. echolalia).

5 Severe, some tics involve lengthy bouts of orchestrated behaviour or speech that would be impossible to camouflage or successfully rationalize as normal because of their duration and/or extremely unusual, inappropriate, bizarre, or obscene character (e.g. copropraxia, or coprolalia).

E. Interference:a)Motor Score: ☐ b) Phonic Score: ☐

0 None

1 Minimal, when tics are present, they do not interrupt the flow of behaviour or speech.

2 Mild, when tics are present, they occasionally interrupt the flow of behaviour or speech

3 Moderate, when tics are present, they frequently interrupt the flow of behaviour or speech.
4 Marked, when tics are present, they frequently interrupt the flow of behaviour or speech, and they occasionally disrupt intended action or communication.
5 Severe, when tics are present, they frequently disrupt intended action or communication.

F. a) Total Motor Tic Score ☐

b) Total Phonic Tic Score ☐

G. Overall Impairment: ☐

0 None.
1 Minimal, tics associated with subtle difficulties in self-esteem, family life, social acceptance, or school or job functioning.
2 Mild, tics associated with minor difficulties in self-esteem family life, social acceptance, or school or job functioning.
3 Moderate, tics associated with some clear problems in self-esteem, family life, social acceptance, or school or job functioning
4 Marked, tics associated with major difficulties in self-esteem, family life, social acceptance, or school or job functioning
5 Severe, tics associated with extreme difficulties in self-esteem, family life, and severely restricted life because of social stigma and social avoidance, removal from school or loss of job.

H. Global Severity Score (overall impairment score x 10 + total motor score + total phonic score) ☐

Appendix XVI: Copy of MOVES

MOVE SURVEY

nswer the questions below for the ıst _week(s)	NEVER	SOMETIMES	OFTEN	ALWAYS
I make noises like grunts that I can't stop				
Parts of my body jerks again and again, ıt I can't control				
I have bad ideas over and over, that I can't ɔp				
I have to do things in a certain order or ıys (like touching things)				
Words come out that I can't stop or ıntrol				
At times I have the same jerk or twitch ɐr and over				
Certain bad words or thoughts keep going ıough my mind				
I have to do exactly the opposite of what ın told				
The same unpleasant or silly thought or ɔture goes through my mind				
I can't control all my movements				
I have to do several movements over and ɐr again, in the same order				
Bad or swear words come out that I ın't mean to say				
I feel pressure to talk, shout or scream				
I have ideas that bother me (like germs ·cutting myself)				
I do certain things (like jumping or ıpping) over and over				
I have habits or movements that come ıt more when I'm nervous				
I have to repeat things that I hear other ɔple say				
I have to do things that I see other people)				
I have to make bad gestures (like the ıger)				
I have to repeat words or phrases over ıd over				

Appendix XVII: Copy of LOI-CV

Participant: _____ Date: _____

(Please circle the correct answers)

1. **Do you often feel like you have to do certain things even though you know you don't really have to?** Yes No

   If yes,

   0 This habit does not stop me from doing other things I want to do.
   1 This stops me a little or wastes a little of my time.
   2 This stops me from doing other things or wastes some of my time.
   3 This stops me from doing a lot of things or wastes a lot of my time.

2. **Do thoughts or words ever keep going over and over in your mind?** Yes No

   If yes,

   0 This habit does not stop me from doing other things I want to do.
   1 This stops me a little or wastes a little of my time.
   2 This stops me from doing other things or wastes some of my time.
   3 This stops me from doing a lot of things or wastes a lot of my time.

3. **Do you have to check things several times?** Yes No

   If yes,

   0 This habit does not stop me from doing other things I want to do.
   1 This stops me a little or wastes a little of my time.
   2 This stops me from doing other things or wastes some of my time.
   3 This stops me from doing a lot of things or wastes a lot of my time.

4. **Do you hate dirt and dirty things?** Yes No

   If yes,

   0 This habit does not stop me from doing other things I want to do.
   1 This stops me a little or wastes a little of my time.
   2 This stops me from doing other things or wastes some of my time.
   3 This stops me from doing a lot of things or wastes a lot of my time.

5. **Do you ever feel that if something has been used or touched by someone else it is spoiled for you?** Yes No

   If yes,

   0 This habit does not stop me from doing other things I want to do.
   1 This stops me a little or wastes a little of my time.
   2 This stops me from doing other things or wastes some of my time.
   3 This stops me from doing a lot of things or wastes a lot of my time.

6. **Do you ever worry about being clean enough?** Yes No

If yes,

0 This habit does not stop me from doing other things I want to do.
1 This stops me a little or wastes a little of my time.
2 This stops me from doing other things or wastes some of my time.
3 This stops me from doing a lot of things or wastes a lot of my time.

7. **Are you fussy about keeping your hands clean?** Yes No

If yes,

0 This habit does not stop me from doing other things I want to do.
1 This stops me a little or wastes a little of my time.
2 This stops me from doing other things or wastes some of my time.
3 This stops me from doing a lot of things or wastes a lot of my time.

8. **When you put things away at night, do they have to be put away just right?** Yes No

If yes,

0 This habit does not stop me from doing other things I want to do.
1 This stops me a little or wastes a little of my time.
2 This stops me from doing other things or wastes some of my time.
3 This stops me from doing a lot of things or wastes a lot of my time.

9. **Do you get angry if other students mess up your desk?** Yes No

If yes,

0 This habit does not stop me from doing other things I want to do.
1 This stops me a little or wastes a little of my time.
2 This stops me from doing other things or wastes some of my time.
3 This stops me from doing a lot of things or wastes a lot of my time.

10. **Do you spend a lot of extra time checking your homework to make sure that it is just right?** Yes No

If yes,

0 This habit does not stop me from doing other things I want to do.
1 This stops me a little or wastes a little of my time.
2 This stops me from doing other things or wastes some of my time.
3 This stops me from doing a lot of things or wastes a lot of my time.

11. **Do you ever have to do things over and over a certain number of times before they seem quite right?** Yes No

If yes,

0 This habit does not stop me from doing other things I want to do.
1 This stops me a little or wastes a little of my time.
2 This stops me from doing other things or wastes some of my time.
3 This stops me from doing a lot of things or wastes a lot of my time.

12. **Do you ever have to count several times or go through numbers in your mind?** Yes No

If yes,

0 This habit does not stop me from doing other things I want to do.
1 This stops me a little or wastes a little of my time.
2 This stops me from doing other things or wastes some of my time.
3 This stops me from doing a lot of things or wastes a lot of my time.

13. **Do you ever have trouble finishing your schoolwork or chores because you have to do something over and over again?** Yes No

If yes,

0 This habit does not stop me from doing other things I want to do.
1 This stops me a little or wastes a little of my time.
2 This stops me from doing other things or wastes some of my time.
3 This stops me from doing a lot of things or wastes a lot of my time.

14. **Do you have a favourite or special number that you like to count up to a lot or do things just that number of times?** Yes No

If yes,

0 This habit does not stop me from doing other things I want to do.
1 This stops me a little or wastes a little of my time.
2 This stops me from doing other things or wastes some of my time.
3 This stops me from doing a lot of things or wastes a lot of my time.

15. **Do you ever have a bad conscience because you've done something even though no one else thinks it is bad?** Yes No

If yes,

0 This habit does not stop me from doing other things I want to do.
1 This stops me a little or wastes a little of my time.
2 This stops me from doing other things or wastes some of my time.
3 This stops me from doing a lot of things or wastes a lot of my time.

16. **Do you worry a lot if you've done something not exactly the way you like?** Yes No

If yes,

0 This habit does not stop me from doing other things I want to do.
1 This stops me a little or wastes a little of my time.
2 This stops me from doing other things or wastes some of my time.
3 This stops me from doing a lot of things or wastes a lot of my time.

17. **Do you have trouble making up your mind?** Yes No

If yes,

0 This habit does not stop me from doing other things I want to do.
1 This stops me a little or wastes a little of my time.
2 This stops me from doing other things or wastes some of my time.
3 This stops me from doing a lot of things or wastes a lot of my time.

18. **Do you go over things a lot that you have done because you aren't sure that they were the right things to do?** Yes No

If yes,

0 This habit does not stop me from doing other things I want to do.
1 This stops me a little or wastes a little of my time.
2 This stops me from doing other things or wastes some of my time.
3 This stops me from doing a lot of things or wastes a lot of my time.

19. **Do you move or talk in just a special way to avoid bad luck?** Yes No

If yes,

0 This habit does not stop me from doing other things I want to do.
1 This stops me a little or wastes a little of my time.
2 This stops me from doing other things or wastes some of my time.
3 This stops me from doing a lot of things or wastes a lot of my time.

20. **Do you have special numbers or words that you say, just because it keeps bad luck away or bad things away?** Yes No

If yes,

0 This habit does not stop me from doing other things I want to do.
1 This stops me a little or wastes a little of my time.
2 This stops me from doing other things or wastes some of my time.
3 This stops me from doing a lot of things or wastes a lot of my time.

BROWN ADD SCALES™

Ready Score® Answer Document

Adolescent

Appendix XVIII: Copy of Brown ADD Scales

Adolescent's Name: _____ ID: _____ Age: _____ Grade: _____

School: _____ Examiner: _____ Date: ___/___/___

ructions to Examiner: Item by item, read to the client each symptom listed, and circle the r number beneath the words that tell how much the client believes that feeling or behavior been a problem in the past 6 months. (Optional: Obtain a collateral's rating of the client after obtaining the client's self-rating. Record by circling the **black** number.)
Note on page 2.

	Never	Once a Week or Less	Twice a Week	Almost Daily
Listens and tries to pay attention in class or in conversation, but mind often drifts; misses out on desired information.	0 0	1 1	2 2	3 3
Has excessive difficulty getting started on tasks such as homework.	0 0	1 1	2 2	3 3
Feels excessively stressed or overwhelmed by tasks that should be manageable (e.g., "no way I can do all this now; this is way too much"—though it really isn't all that bad).	0 0	1 1	2 2	3 3
"Spaces out" involuntarily and frequently when doing assigned reading; keeps thinking of things that have nothing to do with what is being read.	0 0	1 1	2 2	3 3
Is easily sidetracked; starts one task then switches to something less important.	0 0	1 1	2 2	3 3
Loses track in assigned reading of what has just been read and needs to read it again; understands the words, but what was read "just doesn't stick."	0 0	1 1	2 2	3 3
Studies information but cannot remember it easily when it is wanted (e.g., knows it well the night before a test but cannot adequately recall it for test the next day).	0 0	1 1	2 2	3 3
Remembers some of the details in assigned reading but has difficulty grasping the main idea.	0 0	1 1	2 2	3 3
Is easily frustrated and excessively impatient.	0 0	1 1	2 2	3 3
Bogs down when presented with many things to do; has difficulty getting organized and then getting started.	0 0	1 1	2 2	3 3
Procrastinates excessively; keeps putting things off: "I'll do it later," or "I'll do it tomorrow."	0 0	1 1	2 2	3 3
Feels sleepy or tired during the day, even after a decent sleep the night before.	0 0	1 1	2 2	3 3
Gets nervous and "freezes" when taking tests or exams; seems unable to get organized and begin.	0 0	1 1	2 2	3 3
Cannot complete assignments or tests in the time that is given; needs extra time to finish satisfactorily.	0 0	1 1	2 2	3 3
Intends to do things but forgets (e.g., take needed papers to or from school, turn off appliances, return phone calls, keep appointments, do assignments).	0 0	1 1	2 2	3 3
Is criticized by others or self for being lazy.	0 0	1 1	2 2	3 3
Produces inconsistent quality of work; performance quite variable (e.g., high grades and low grades in same subject for no apparent reason).	0 0	1 1	2 2	3 3
Is sensitive to criticism from others; feels it deeply or for a long time; gets overly defensive.	0 0	1 1	2 2	3 3
Tends to be slow to react or to get started, sluggish or slow-moving; doesn't jump right into things; slow to answer questions or to get ready to do something.	0 0	1 1	2 2	3 3
Becomes irritated easily; "short-fused" with sudden outbursts of anger.	0 0	1 1	2 2	3 3

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0154029459

BROWN ADD SCALES™

Ready Score® Answer Document

Adolescent

	Never	Once a Week or Less	Twice a Week	Almost Daily
1. Is excessively rigid or is a perfectionist (has to get things just so,"picky, picky, picky").	0 0	1 1	2 2	3 3
2. Receives criticism for not working up to potential (e.g., "could do so much better if only . . . would try harder or work more consistently").	0 0	1 1	2 2	3 3
3. Gets lost in daydreaming or is preoccupied with own thoughts.	0 0	1 1	2 2	3 3
4. Has difficulty expressing anger appropriately to others; doesn't stand up for self.	0 0	1 1	2 2	3 3
5. "Runs out of steam" and doesn't follow through; effort fades quickly.	0 0	1 1	2 2	3 3
6. Is easily distracted from tasks by background noises or activities; needs to check out whatever else is going on.	0 0	1 1	2 2	3 3
7. Is hard to wake up in the morning; finds it difficult to get out of bed and to get going.	0 0	1 1	2 2	3 3
8. In writing, must repeatedly erase, scratch out, or start over because of minor mistakes.	0 0	1 1	2 2	3 3
9. Frequently feels discouraged, depressed, sad, or down.	0 0	1 1	2 2	3 3
10. Tends to be a loner among peers; keeps to self and is shy; doesn't play or talk much with friends of same age.	0 0	1 1	2 2	3 3
11. Appears apathetic or unmotivated (others think he/she doesn't care at all about his/her work).	0 0	1 1	2 2	3 3
12. Stares off into space; seems "out of it."	0 0	1 1	2 2	3 3
13. Often leaves out words or letters in writing.	0 0	1 1	2 2	3 3
14. Has sloppy, hard-to-read penmanship.	0 0	1 1	2 2	3 3
15. Forgets to bring—or loses track of—needed items, such as keys, textbooks, pencils, completed assignments ("I know it's here someplace; I just can't find it right now . . . ").	0 0	1 1	2 2	3 3
16. Doesn't seem to be listening and gets complaints about it from teachers and others.	0 0	1 1	2 2	3 3
17. Needs to be reminded by teachers or others to get started or to keep working on assigned tasks.	0 0	1 1	2 2	3 3
18. Has difficulty memorizing (e.g., vocabulary, math facts, names, dates).	0 0	1 1	2 2	3 3
19. Misunderstands directions for assignments.	0 0	1 1	2 2	3 3
20. Starts tasks (e.g., homework, chores) but doesn't finish them.	0 0	1 1	2 2	3 3

ote. Collateral responses are collected only for the clinical value the information and are not used for diagnostic purposes.

Total the black numbers for Items 1–40 to obtain the collateral score: _____

3456789101112ABCDE

2

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Appendix XIX: Copy of MESSY

Participant: _____ Date: _____

This survey is a measure of social behaviour. This assessment involves rating how often you do the behaviours or feel like it says in the survey. Be sure to rate how often each behaviour is done, not what you think a good answer would be.

Rating Scale:

1 NOT AT ALL
2 A LITTLE
3 SOME
4 MUCH OF THE TIME
5 VERY MUCH

(Please circle the correct number)

1.	I make other people laugh (tell jokes, funny stories, etc.).	1	2	3	4	5
2.	I threaten people or act like a bully.	1	2	3	4	5
3.	I become angry easily.	1	2	3	4	5
4.	I am bossy (tell people what to do instead of asking).	1	2	3	4	5
5.	I gripe or complain often.	1	2	3	4	5
6.	I speak (break in) when someone else is speaking.	1	2	3	4	5
7.	I take or use things that are not mine without permission.	1	2	3	4	5
8.	I brag about myself.	1	2	3	4	5
9.	I look at people when I talk to them.	1	2	3	4	5
10.	I have many friends.	1	2	3	4	5
11.	I slap or hit when I am angry.	1	2	3	4	5
12.	I help a friend who is sad.	1	2	3	4	5
13.	I cheer up a friend who is hurt.	1	2	3	4	5
14.	I give other children dirty looks.	1	2	3	4	5
15.	I feel angry or jealous when someone else does well.	1	2	3	4	5
16.	I feel happy when someone else does well.	1	2	3	4	5
17.	I pick out other children's faults/mistakes.	1	2	3	4	5
18.	I always want to be first.	1	2	3	4	5
19.	I break promises.	1	2	3	4	5
20.	I tell people they look nice.	1	2	3	4	5
21.	I lie to get something I want.	1	2	3	4	5
22.	I pick on people to make them angry.	1	2	3	4	5
23.	I walk up to people and start a conversation.	1	2	3	4	5
24.	I say "thank you" and am happy when someone does something for me.	1	2	3	4	5
25.	I like to be alone.	1	2	3	4	5

26.	I am afraid to speak to people.	1	2	3	4	5
27.	I keep secrets well.	1	2	3	4	5
28.	I know how to make friends.	1	2	3	4	5
29.	I hurt others' feelings on purpose (I try to make people sad.)	1	2	3	4	5
30.	I make fun of others.	1	2	3	4	5
31.	I stick up for my friends.	1	2	3	4	5
32.	I look at people when they are speaking.	1	2	3	4	5
33.	I think I know it all.	1	2	3	4	5
34.	I share what I have with others.	1	2	3	4	5
35.	I am stubborn.	1	2	3	4	5
36.	I act as if I am better than other people.	1	2	3	4	5
37.	I show my feelings.	1	2	3	4	5
38.	I think people are picking on me when they are not.	1	2	3	4	5
39.	I make sounds that bother others (e.g., burping, sniffing).	1	2	3	4	5
40.	I take care of others' property as if it were my own.	1	2	3	4	5
41.	I speak too loudly.	1	2	3	4	5
42.	I call people by their names.	1	2	3	4	5
43.	I ask if I can be of help.	1	2	3	4	5
44.	I feel good if I help someone.	1	2	3	4	5
45.	I try to be better than everyone else.	1	2	3	4	5
46.	I ask questions when talking with others.	1	2	3	4	5
47.	I see my friends often.	1	2	3	4	5
48.	I play alone.	1	2	3	4	5
49.	I feel lonely.	1	2	3	4	5
50.	I feel sorry when I hurt someone.	1	2	3	4	5
51.	I like to be the leader.	1	2	3	4	5
52.	I join in activities/games with other children.	1	2	3	4	5
53.	I get into fights a lot.	1	2	3	4	5
54.	I am jealous of other people.	1	2	3	4	5
55.	I do nice things for people who are nice to me.	1	2	3	4	5
56.	I ask others how they are, what they have been doing, etc.	1	2	3	4	5
57.	I stay with others too long (wear out my welcome).	1	2	3	4	5
58.	I explain things more than necessary.	1	2	3	4	5
59.	I laugh at other people.	1	2	3	4	5
60.	I think that winning is everything.	1	2	3	4	5
61.	I hurt others' feelings when teasing them.	1	2	3	4	5
62.	I want to get even with someone who hurts me.	1	2	3	4	5

Appendix XX: Copy of CBCL

CHILD BEHAVIOR CHECKLIST FOR AGES 4–18

For office use only
ID #

ease Print

ILD'S FIRST MIDDLE LAST
LL
ME

X
Boy Girl

AGE

ETHNIC GROUP OR RACE

DAY'S DATE
Date Yr.

CHILD'S BIRTHDATE
Mo. Date Yr.

ADE IN HOOL

T ATTENDING HOOL ☐

Please fill out this form to reflect *your* view of the child's behavior even if other people might not agree. Feel free to print additional comments beside each item and in the spaces provided on page 2.

PARENTS' USUAL TYPE OF WORK, even if not working now. *(Please be specific—for example, auto mechanic, high school teacher, homemaker, laborer, lathe operator, shoe salesman, army sergeant.)*

FATHER'S TYPE OF WORK: _____

MOTHER'S TYPE OF WORK: _____

THIS FORM FILLED OUT BY:

☐ Mother (full name) _____

☐ Father (full name) _____

☐ Other—full name & relationship to child: _____

Please list the sports your child most likes to take part in. For example: swimming, baseball, skating, skate boarding, bike riding, fishing, etc.

☐ None

Compared to others of the same age, about how much time does he/she spend in each?

	Don't Know	Less Than Average	Average	More Than Average
a. _____	☐	☐	☐	☐
b. _____	☐	☐	☐	☐
c. _____	☐	☐	☐	☐

Compared to others of the same age, how well does he/she do each one?

	Don't Know	Below Average	Average	Above Average
a. _____	☐	☐	☐	☐
b. _____	☐	☐	☐	☐
c. _____	☐	☐	☐	☐

Please list your child's favorite hobbies, activities, and games, other than sports. For example: stamps, dolls, books, piano, crafts, cars, singing, etc. (Do ***not*** include listening to radio or TV.)

☐ None

Compared to others of the same age, about how much time does he/she spend in each?

	Don't Know	Less Than Average	Average	More Than Average
a. _____	☐	☐	☐	☐
b. _____	☐	☐	☐	☐
c. _____	☐	☐	☐	☐

Compared to others of the same age, how well does he/she do each one?

	Don't Know	Below Average	Average	Above Average
a. _____	☐	☐	☐	☐
b. _____	☐	☐	☐	☐
c. _____	☐	☐	☐	☐

Please list any organizations, clubs, teams, or groups your child belongs to.

☐ None

Compared to others of the same age, how active is he/she in each?

	Don't Know	Less Active	Average	More Active
a. _____	☐	☐	☐	☐
b. _____	☐	☐	☐	☐
c. _____	☐	☐	☐	☐

Please list any jobs or chores your child has. For example: paper route, babysitting, making bed, working in store, etc. (Include ***both*** paid and unpaid jobs and chores.)

☐ None

Compared to others of the same age, how well does he/she carry them out?

	Don't Know	Below Average	Average	Above Average
a. _____	☐	☐	☐	☐
b. _____	☐	☐	☐	☐
c. _____	☐	☐	☐	☐

Please Print

V. 1. About how many close friends does your child have? ☐ None ☐ 1 ☐ 2 or 3 ☐ 4 or more
(Do *not* include brothers & sisters)

2. About how many times a week does your child do things with any friends outside of regular school hours?
(Do *not* include brothers & sisters) ☐ Less than 1 ☐ 1 or 2 ☐ 3 or more

VI. Compared to others of his/her age, how well does your child:

	Worse	About Average	Better	
a. Get along with his/her brothers & sisters?	☐	☐	☐	☐ Has no brothers or sisters
b. Get along with other kids?	☐	☐	☐	
c. Behave with his/her parents?	☐	☐	☐	
d. Play and work alone?	☐	☐	☐	

VII. 1. For ages 6 and older—performance in academic subjects. ☐ Does not attend school because _____

Check a box for each subject that child takes	Failing	Below Average	Average	Above Average
a. Reading, English, or Language Arts	☐	☐	☐	☐
b. History or Social Studies	☐	☐	☐	☐
c. Arithmetic or Math	☐	☐	☐	☐
d. Science	☐	☐	☐	☐
Other academic subjects—for example: computer courses, foreign language, business. Do ***not*** include gym, shop, driver's ed., etc. e. _____	☐	☐	☐	☐
f. _____	☐	☐	☐	☐
g. _____	☐	☐	☐	☐

2. Does your child receive special remedial services or attend a special class or special school? ☐ No ☐ Yes—kind of services, class, or school:

3. Has your child repeated any grades? ☐ No ☐ Yes—grades and reasons:

4. Has your child had any academic or other problems in school? ☐ No ☐ Yes—please describe:

When did these problems start?

Have these problems ended? ☐ No ☐ Yes—when?

oes your child have any illness or disability (either physical or mental)? ☐ No ☐ Yes—please describe:

hat concerns you most about your child?

lease describe the best things about your child:

Below is a list of items that describe children and youth. For each item that describes your child ***now or within the past 6 months***, please circle the ***2*** if the item is ***very true or often true*** of your child. Circle the ***1*** if the item is ***somewhat or sometimes true*** of your child. If the item is ***not true*** of your child, circle the ***0***. Please answer all items as well as you can, even if some do not seem to apply to your child.

Please Print

0 = Not True (as far as you know) 1 = Somewhat or Sometimes True 2 = Very True or Often True

1 2 1. Acts too young for his/her age
1 2 2. Allergy (describe): _____
_____
1 2 3. Argues a lot
1 2 4. Asthma
1 2 5. Behaves like opposite sex
1 2 6. Bowel movements outside toilet
1 2 7. Bragging, boasting
1 2 8. Can't concentrate, can't pay attention for long
1 2 9. Can't get his/her mind off certain thoughts; obsessions (describe): _____
_____
1 2 10. Can't sit still, restless, or hyperactive
1 2 11. Clings to adults or too dependent
1 2 12. Complains of loneliness
1 2 13. Confused or seems to be in a fog
1 2 14. Cries a lot
1 2 15. Cruel to animals
1 2 16. Cruelty, bullying, or meanness to others
1 2 17. Day-dreams or gets lost in his/her thoughts
1 2 18. Deliberately harms self or attempts suicide
1 2 19. Demands a lot of attention
1 2 20. Destroys his/her own things
1 2 21. Destroys things belonging to his/her family or others
1 2 22. Disobedient at home
1 2 23. Disobedient at school
1 2 24. Doesn't eat well
1 2 25. Doesn't get along with other kids
1 2 26. Doesn't seem to feel guilty after misbehaving
1 2 27. Easily jealous
1 2 28. Eats or drinks things that are not food—***don't*** include sweets (describe): _____
_____
1 2 29. Fears certain animals, situations, or places, other than school (describe): _____
_____
1 2 30. Fears going to school
0 1 2 31. Fears he/she might think or do something bad
0 1 2 32. Feels he/she has to be perfect
0 1 2 33. Feels or complains that no one loves him/her
0 1 2 34. Feels others are out to get him/her
0 1 2 35. Feels worthless or inferior
0 1 2 36. Gets hurt a lot, accident-prone
0 1 2 37. Gets in many fights
0 1 2 38. Gets teased a lot
0 1 2 39. Hangs around with others who get in trouble
0 1 2 40. Hears sounds or voices that aren't there (describe): _____
_____
0 1 2 41. Impulsive or acts without thinking
0 1 2 42. Would rather be alone than with others
0 1 2 43. Lying or cheating
0 1 2 44. Bites fingernails
0 1 2 45. Nervous, highstrung, or tense
0 1 2 46. Nervous movements or twitching (describe):
_____
_____
0 1 2 47. Nightmares
0 1 2 48. Not liked by other kids
0 1 2 49. Constipated, doesn't move bowels
0 1 2 50. Too fearful or anxious
0 1 2 51. Feels dizzy
0 1 2 52. Feels too guilty
0 1 2 53. Overeating
0 1 2 54. Overtired
0 1 2 55. Overweight
56. Physical problems ***without known medical cause:***
0 1 2 a. Aches or pains (***not*** stomach or headaches)
0 1 2 b. Headaches
0 1 2 c. Nausea, feels sick
0 1 2 d. Problems with eyes (***not*** if corrected by glasses) (describe): _____
0 1 2 e. Rashes or other skin problems
0 1 2 f. Stomachaches or cramps
0 1 2 g. Vomiting, throwing up
0 1 2 h. Other (describe): _____
_____

Please see other side

0 = Not True (as far as you know) 1 = Somewhat or Sometimes True 2 = Very True or Often True

1 2 57. Physically attacks people
1 2 58. Picks nose, skin, or other parts of body (describe): _____
_____
1 2 59. Plays with own sex parts in public
1 2 60. Plays with own sex parts too much
1 2 61. Poor school work
1 2 62. Poorly coordinated or clumsy
1 2 63. Prefers being with older kids
1 2 64. Prefers being with younger kids
1 2 65. Refuses to talk
1 2 66. Repeats certain acts over and over; compulsions (describe): _____
_____
1 2 67. Runs away from home
1 2 68. Screams a lot
1 2 69. Secretive, keeps things to self
1 2 70. Sees things that aren't there (describe):
_____
_____
1 2 71. Self-conscious or easily embarrassed
1 2 72. Sets fires
1 2 73. Sexual problems (describe): _____
_____
_____
1 2 74. Showing off or clowning
1 2 75. Shy or timid
1 2 76. Sleeps less than most kids
1 2 77. Sleeps more than most kids during day and/or night (describe): _____
_____
1 2 78. Smears or plays with bowel movements
1 2 79. Speech problem (describe): _____
_____
1 2 80. Stares blankly
1 2 81. Steals at home
1 2 82. Steals outside the home
1 2 83. Stores up things he/she doesn't need (describe): _____
_____

0 1 2 84. Strange behavior (describe): _____
_____
0 1 2 85. Strange ideas (describe): _____
_____
0 1 2 86. Stubborn, sullen, or irritable
0 1 2 87. Sudden changes in mood or feelings
0 1 2 88. Sulks a lot
0 1 2 89. Suspicious
0 1 2 90. Swearing or obscene language
0 1 2 91. Talks about killing self
0 1 2 92. Talks or walks in sleep (describe): _____
_____
0 1 2 93. Talks too much
0 1 2 94. Teases a lot
0 1 2 95. Temper tantrums or hot temper
0 1 2 96. Thinks about sex too much
0 1 2 97. Threatens people
0 1 2 98. Thumb-sucking
0 1 2 99. Too concerned with neatness or cleanliness
0 1 2 100. Trouble sleeping (describe): _____
_____
0 1 2 101. Truancy, skips school
0 1 2 102. Underactive, slow moving, or lacks energy
0 1 2 103. Unhappy, sad, or depressed
0 1 2 104. Unusually loud
0 1 2 105. Uses alcohol or drugs for nonmedical purposes (describe): _____
_____
0 1 2 106. Vandalism
0 1 2 107. Wets self during the day
0 1 2 108. Wets the bed
0 1 2 109. Whining
0 1 2 110. Wishes to be of opposite sex
0 1 2 111. Withdrawn, doesn't get involved with others
0 1 2 112. Worries

113. Please write in any problems your child has that were not listed above:

0 1 2 _____
0 1 2 _____
0 1 2 _____

ASE BE SURE YOU HAVE ANSWERED ALL ITEMS. UNDERLINE ANY YOU ARE CONCERNED ABOUT.