Emotional Processing Deficits in Parkinson's Disease

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Thesis submitted in fulfilment of the requirements for the degree of Doctor of Clinical Neuropsychology/Master of Science

School of Psychology

The University of Sydney

June 2008

Preface

This thesis was undertaken in the School of Psychology at the University of Sydney, under the supervision of Dr. Diana Caine and Dr. Margaret Charles, while I was enrolled in the Doctor of Clinical Neuropsychology/Master of Science degree program.

I declare that this submission constitutes my own work and has not been previously published or written by another person. It has not been submitted for a degree at any other university. Throughout the body of this paper, acknowledgement has been made to other authors or institutions when their work or ideas have been used.

Author's Name _____

Author's Signature _____

ACKNOWLEDGMENTS

I would like to thank my supervisor, Dr. Diana Caine, who first piqued my interest in the "emotional" side of neuropsychology. From the first day I started my project through to the conclusion, she has provided guidance, encouragement and most beneficial of all, expertise. She remained a support for me despite her career taking her across the globe. Her knowledge and input during each phase of this project from forming ideas to forming conclusions – have both stimulated my curiosity and motivated me to keep going when my enthusiasm was lagging. While providing this support, she has allowed me the freedom of thought to develop my own ideas and to feel at the end of this project that I have made a significant accomplishment.

I would also like to thank my other supervisor, Dr Margaret Charles, who boldly agreed to sign on to my project late in the process. She has provided valuable support in guiding me through the sometimes treacherous world of statistical analyses. I am grateful for her patience and willingness to listen to my ideas while providing a clear direction on the best way to get the information that I sought. I learned a great deal.

I would like to acknowledge my associate supervisor, Dr. Nora Breen, who willingly signed on to my project early on. She provided encouragement and support during departmental research presentations and with various ad hoc questions along the way. I very much appreciate the help of Ms Larraine McAnally from the Movement Disorders Clinic at Westmead Hospital who was vital in providing assistance in patient recruitment over an extended period of time.

Lastly, I would like to thank my family - my husband, Neil, and my children, Ben and Jacqueline - to whom I owe not only gratitude but endless favours. When I first decided to change careers and study psychology, little did I (or they) know that nine years later, after an undergraduate and now graduate degree, I would *just* be finishing. My family has truly suffered through my endless late nights and consequent "grumpy" mornings and occasional missed family outings. They have been a source of great strength for me, and I couldn't have accomplished what I have without them.

ABSTRACT

Introduction: Parkinson's disease (PD) is known to cause detrimental effects to motor function and cognition. The motor effects of the disease in turn impact emotion *expression* in patients with PD. There is conflicting evidence in research, however, as to whether PD also affects emotion comprehension, and if so, what emotions in particular are affected and across what modalities. This study aimed to investigate the effects of PD on a broad range of skills involved in basic and complex emotion comprehension. Whether these effects extend into other areas associated with emotion processing, such as social cognition and autobiographical memory, was also explored.

Methods: Sixteen patients with PD participated in the study along with sixteen control subjects who were matched for age, gender, education level and estimated premorbid intelligence. The PD participants, on average, were in the moderate phase of the disease and taking PD medication, including dopamine. Participants were tested on a range of recognition measures including prototypical and morphed facial expressions with reduced intensity (40 and 80%), emotion prosody, written emotion vignettes, emotional imagery, pictures of emotion, social cognition, and a cued autobiographical memory task. A mood inventory was given, and disease severity and duration were noted.

Results: The PD group did not show pervasive deficits in emotion recognition overall. Deficits were demonstrated in prosody recognition, specifically with fearful tones, and in an incongruent prosody task, specifically with angry and neutral tones. The PD group was not able to recognise facial expressions of disgust (mixed intensities) as well as controls, with the result showing a trend toward significance. PD participants were also significantly worse in Theory of Mind (TOM) reasoning but not at another social cognition measure involving recognising social emotions through expressions from the eyes only. There were no differences between the groups across all other tests.

Discussion: PD is thought to cause subtle deficits in emotion comprehension which are only elucidated through complex tasks. The effects of PD on complex processing also impact TOM performance, which relies on skills involved in complex emotion recognition. Effects of mood and disease factors on performance were circumscribed. Evidence suggested that the basal ganglia and fronto-striatal connections play a role in emotion comprehension.

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CHAPTER 1: INTRODUCTION

1.1 What is Parkinson's disease?

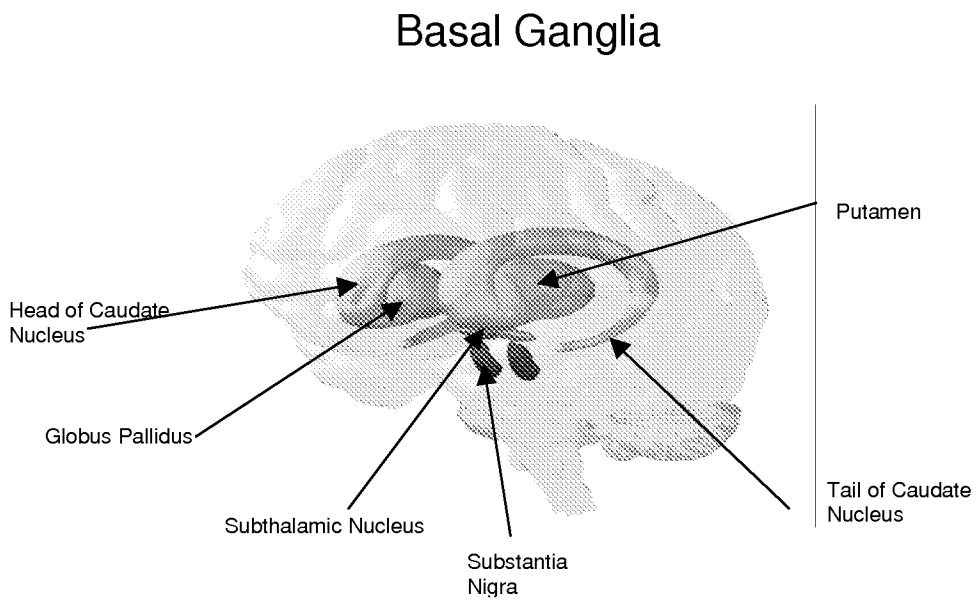
Parkinson's disease (PD) is a progressive, neurodegenerative disorder that is characterized by four classic motor signs: bradykinesia (slowing of movement), a resting tremour, rigidity, and asymmetric onset. Other motor symptoms that are not critical for diagnosis but are commonly present at later stages of the disease are postural instability, shuffling gait, micrographia (small handwriting), eye movement abnormalities, and swallowing difficulties (Gelb, Oliver, & Gilman, 1999; Rao, Huber, & Bornstein, 1992). It is important when diagnosing PD to clarify the distinction between PD and people suffering from non-idiopathic Parkinson's syndrome. Although the latter condition involves similar motor signs, the causes are known and can be attributed to vascular disease, encephalitis, or synthetic drugs such as MPTP, in which symptoms cease following drug withdrawal. In contrast, the aetiology of PD is largely unknown and, therefore, termed idiopathic PD. Recent evidence, however, suggests that both environmental and genetic factors may play a role. For instance, it has been proposed that people with PD may have a genetic predisposition making their brains more vulnerable to pesticides or other environmental toxins (Marsden, 1994). The incidence of PD in the general population is approximately 1 in 1000. Although it can be diagnosed at younger ages such as a person's thirties or forties, peak incidence occurs in the sixth decade of life (Rao et al., 1992).

1.11 Neuropathology of PD

The pathology of PD has two distinctive features. It is characterised by the presence of Lewy bodies and the degeneration of dopaminergic neurons in the substantia nigra

pars compacta (SNpc), which is located in the midbrain and forms part of the basal ganglia (Marsden, 1994).

Figure 1-1
Components of the basal ganglia



The most striking cell loss from PD occurs in the ventrolateral portion of the SNpc, which projects to the dorsolateral putamen. To a lesser degree, degeneration occurs in the dorsal part of the SNpc, which projects to the caudate nucleus, in the retrorubal region, which projects to the hypothalamus, and in the ventral tegmental area, which projects to the ventral striatum, amygdala, hippocampus, and areas of the frontal lobe including the motor, premotor, rhinal, cingulate, and prefrontal cortices (Damier, Hirsch, Agid, & Graybiel, 1999).

Recent evidence suggests that the basal ganglia, thalamus, and cortical structures form five adjacent and anatomically separate circuits. These five circuits link subcortical

areas with motor, oculomotor, dorsolateral prefrontal, lateral orbitofrontal and anterior cingulate cortices. Within each circuit, there are two parallel pathways (direct and indirect) that have opposing influences on basal ganglia output. For instance, when considering the motor circuit of the basal ganglia, the direct pathway has a net excitatory effect on output of increasing movement while the indirect pathway has a net inhibitory effect of decreasing movement (Alexander & Crutcher, 1990; Mandir & Vaughan, 2000). See image below.

Figure 1-2
Direct and indirect pathways of the basal ganglia-thalamocortical circuit (Alexander & Crutcher, 1990).

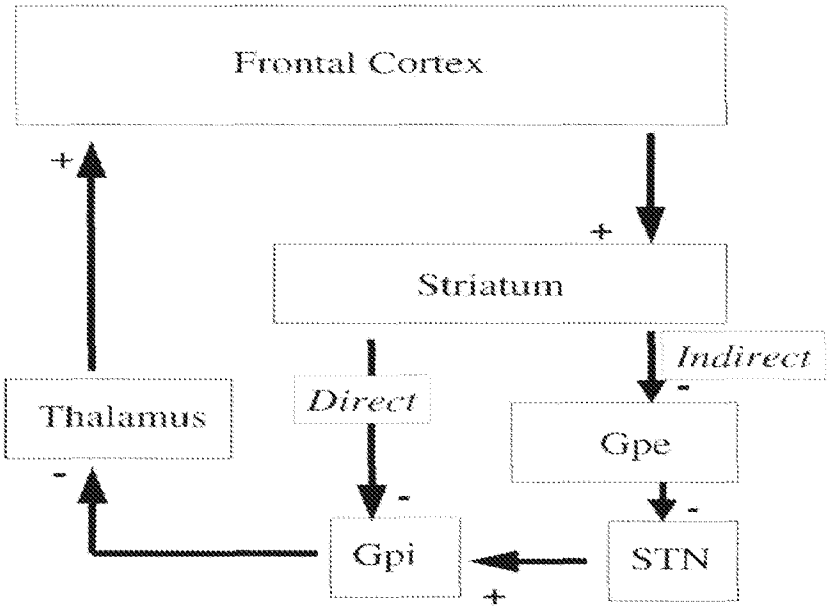


Figure 1. *A model of the cortical-subcortical loops.*

Disruption to the basal ganglia-thalamocortical circuits as a result of PD may explain the varied disturbances to movement, cognition, and mood. The main target of the motor cortices is the putamen. This may explain some of the motor symptoms of PD. In addition, the dorsolateral prefrontal and lateral orbital circuits project to the caudate

nucleus and are thought to be involved in the programming of movement and cognition. The anterior cingulate projects to the ventral striatum, and damage to this area of the basal ganglia may explain affective disturbances in PD.

1.2 Cognitive Deficits in PD

Investigations of the cognitive disturbances in PD have mainly focused on higher order processing or executive function and can be observed early in the course of the disease (Levin, LLabre, & Weiner, 1988). Several studies have found deficits on tests of executive function such as working memory, complex attention, abstract reasoning, planning, and problem-solving (Lewis, Dove, Robbins, Barker, & Owen, 2003; Monchi et al., 2004; Peavy et al., 2001). In a review of the literature on cognitive impairment in PD, Mindham and Hughes (2000) found that impairments in working memory and set shifting (changing behaviour according to a new set of rules) were common in PD. They also reported evidence of general cognitive slowing unrelated to the slowing of motor function.

Farina et al. (2000) tested people with PD early in the course of their disease (I-II Hoehn and Yahr stage) on tests of executive function and memory. They hypothesised that visual memory would be more affected in PD than verbal memory due to previous evidence of poor visuospatial function. Although they found that participants with PD performed worse on tests of set shifting and maintaining set as expected, they did not find differential impairment in verbal and visual memory. PD participants performed worse on free recall tasks indicating a difficulty with retrieval while no deficits were shown in learning or delayed recall. In fact, memory deficits in PD have been useful as a point of differentiation with the memory deficits seen in

Alzheimers disease (AD). AD impacts the encoding of memory and, consequently, performance is poor across all recall tasks, i.e. recognition, cued recall, and free recall. In PD, however, information is well-encoded and performance on recognition tasks and cued recall is on par with controls. They show deficits in free recall tasks due to faulty retrieval (Helkala, Laulumaa, Soininen, & Reikkinen, 1988).

Given the circumscribed nature of the memory impairment in PD, there is growing evidence that difficulty in retrieval may be secondary to executive impairment. Higginson et al. (2003) examined the relationship between executive function deficits, particularly working memory, and delayed verbal recall in participants with PD. They found that performance on several executive function tasks was significantly related to performance on delayed verbal recall tasks. However, working memory was the only significant predictor of performance in verbal recall. These results lend support to the hypothesis that memory deficits in PD are secondary to executive function impairment and in particular, working memory.

1.3 Affective Disturbances in PD

In addition to the motor and cognitive deficits seen in PD, neuropsychiatric disturbances represent a third significant area of impairment in the disease. A range of psychiatric conditions is associated with the disease. A study by Aarsland et al. (1999) investigated psychiatric illnesses among 139 participants with PD. They found that 61% of the sample had experienced at least one psychiatric symptom. Depression was the most common affecting 38% of the sample, followed by 27% with hallucinations, and 20% with anxiety. Psychiatric symptoms were found to be

significantly related to disease severity and cognitive impairment, suggesting that they may be a reaction to increasing motor and cognitive limitations.

In contrast to depressive symptoms, depressive syndromes in PD have been attributed to physiological processes of the disease itself or to medication side-effects (Marsh, 2000). In a review of emotional disorders in PD, Rao et al. (1992) concluded that depression was the most common emotional disturbance with most studies reporting prevalence rates of 40-50%. Depression was found to be more prevalent and severe in PD when compared to other equally debilitating neurological conditions. This observation suggested that depression in PD may reflect a depressive syndrome due to organic causes in addition to psychological reactions to the disease. In fact, they reported that 20-30% of people had a previous history of depression before the onset of PD, raising the possibility that depression may be an early prodromal sign of PD, predating motor symptoms.

Similar to depression, there is an increased incidence of anxiety in PD. Anxiety disorders, including generalised anxiety disorder, social phobia or panic disorder, occur in up to 40% of PD patients. While Marsh (2000) argued that symptoms of anxiety may occur as a reaction to the disease, anxiety *syndromes* are thought to be related to underlying disease processes rather than a psychological response to the disease. Evidence for this comes from studies that have found anxiety syndromes to predate the onset of motor symptoms of the disease (Marsh, 2000; Stein, Heuser, Juncos, & Uhde, 1990).

1.4 Emotion Expression in PD

Affective disturbances, such as depression and anxiety, can have an impact on the amount of emotion a person displays. In fact, facial expressions along with other displays of emotion are often blunted in depression (APA, 2000). On the other hand, it has been well established that people with PD have blunted facial displays of emotion. Smith, Smith and Ellgring (1996) compared facial expressions among PD participants and controls when viewing emotionally-charged video clips. They found that participants with PD showed significantly less overall facial reactivity than controls. A diminished display of emotion has also been found when examining *prosody* (a nonverbal feature of language that conveys information through pitch, intonation, melody, cadence, loudness, timbre, tempo, stress, accent, and pauses) in patients with PD. Emotion prosody, conveys affective information to the listener (Feinberg & Farah, 2003). Examining the production of facial expressions and emotion prosody among participants with PD, Borod et al. (1990) reported that PD patients produced significantly less accurate facial expressions, and that they were less accurate and intense when expressing emotion prosody.

Although blunting of psychomotor expression is commonly found in both depression and in PD, this phenomenon is not necessarily caused by depression. Research has found that blunted facial expressions in PD is significantly associated with the motor effects of the disease as well (Marsh, 2000; Simons, Ellgring, & Pasqualini, 2003). Madeley, Ellis and Mindham (1995) reported that the facial expressions of PD patients were less identifiable than controls while there were no differences between the two groups on measures of depression. Similar results were found when Benke et al. (1998) tested participants with PD on tasks involving the production of emotion

prosody. They found that although PD patients were less expressive than controls, their performance was not associated with depression.

1.5 Emotion Comprehension in PD

The combination of deficits in emotion expression and higher level cognition in PD led researchers to question whether the impact of the disease may also extend to complex emotion processing, i.e. the understanding of emotions. Emotion comprehension involves the perception of the particular attributes of an emotion and the ability to mentally assign a "label" to these attributes. In order to examine emotion comprehension in PD, researchers have operationalised this construct by measuring performance on tasks involving the perception, discrimination, and recognition of facial expressions and emotion prosody. Tests of discrimination require the participant to judge whether displayed emotions are the same or different from each other, without explicitly naming the emotion. Recognition tasks, however, are more difficult in that they require participants to discriminate between emotions and label/name them (Pell, 1996). Although the "perception" of emotion is often used interchangeably with discrimination and recognition, a task that strictly measures only "perception" should not require an explicit response on the part of the participant. For the purpose of this paper, emotion "perception" is defined as the initial physiological response of the brain when registering a display of emotion.

1.51 Is emotion comprehension secondary to cognitive deficits in PD?

Early research on emotion understanding in PD focused on the comprehension of the six basic emotions, namely happy, sad, anger, fear, disgust and surprise. Most studies have used the discrimination or recognition of facial expressions and emotion prosody

as measures for emotion comprehension. Several have found deficits in the ability of participants with PD to recognise emotions. Beatty et al. (1989) tested participants with PD on two recognition tasks. The first task involved the recognition of facial expressions using Ekman and Friesen's (1976) standardised set of prototypical photographs. The second task was face recognition, which measured their ability to recognise faces (without expressions) and served as a control measure. Participants with PD were more inaccurate than controls at recognising all the basic emotions, with their performance across emotions being equally impaired. They also performed worse on the face recognition test, which accounted for a large part of the variance in their performance on the emotion test. Beatty et al. (1989) concluded that the inaccuracy of the PD patients on facial expressions was not an emotion processing deficit per se. Rather, it was secondary to cognitive factors, such as their impaired ability to recognise facial features. However, they included PD patients who scored below the dementia cut-off score on the Mini Mental Status Examination (MMSE), a dementia screening measure. Thus, dementia may have been a confounding factor in their study.

In contrast, Pell (1996) compared the performance of cognitively intact (determined by a dementia screening measure and clinical observation) PD participants to controls on emotion prosody tasks that either involved discriminating prosody (low level processing) or recognising prosody (complex processing). He found that the PD group had a similar pattern of performance to controls on emotion prosody discrimination but showed impairment on recognition tasks. He concluded that deficits in emotion prosody are of a quantitative rather than qualitative nature and are not associated with deficits in cognition.

Benke, Bosch, and Andree (1998) compared participants with PD and intact cognitive functions to PD patients with mild to moderate cognitive dysfunction but no dementia and age-matched controls on emotion prosody production and discrimination tasks. The PD group with intact cognition was only impaired on the production of emotion prosody while the PD group with mild to moderate cognitive deterioration was significantly impaired on both prosody tasks. The authors concluded that emotion recognition does not have a separate neural basis but is dependent on intact cognition. They suggested that deficits in emotion processing may be an early indicator for dementia.

There are two important points to make regarding their findings. The fact that the PD group with cognitive dysfunction had deficits in memory function, including cued recall, is surprising. This type of memory impairment is not commonly found in PD and suggests that these participants may have been in a prodrome phase of a dementia unrelated to PD, which was affecting their performance on emotion processing tasks. Secondly, the absence of deficits in prosody discrimination among the cognitively intact PD group may be explained by task difficulty. Low level discrimination tasks are not always sensitive enough to highlight inefficiencies in processing of emotion prosody compared to recognition tasks (see also Pell, 1996).

Breitenstein, Lancker, Daum, and Waters (2001) compared a PD group in the early phase of the disease and not yet on dopamine therapy with a group who had the disease for 4-5 years and were on dopamine therapy on tasks measuring emotion prosody and acoustic parameters (speech rate and pitch). PD patients in the moderate disease phase were impaired at recognising emotion prosody in sentences whose

meaning was incongruent to the prosodic message, e.g. a sentence having "sad" content delivered in a happy tone of voice. The four emotions tested (happy, angry, sad or neutral) were equally affected. Moderate stage PD patients were also impaired at processing speech rate information but not pitch. Working memory and temporal processing were significant predictors of performance on prosody tasks for both groups of PD patients. Their findings confirmed the view that cognition plays a role in the comprehension of emotion prosody.

Findings from Pell and Leonard (2003) supported the view that emotion comprehension is distinct from cognition. They examined the performance of PD participants on tests of emotion prosody discrimination, recognition and feature rating, a task which did not involve working memory. Participants with PD were significantly worse than controls when rating features of disgust and sadness and in recognising pure emotion prosody without semantic information. Deficits in prosody feature rating suggest that there is a separate neural substrate for some aspects of prosody recognition, which do not rely on cognition.

A study by Dara, Monetta, and Pell (2008) asked PD participants to rate the affective properties, i.e. valence and intensity, of vocal emotion stimuli. The PD group was significantly impaired on recognition tasks of pure prosody while they performed similarly to controls if provided with semantic cues. PD patients were less sensitive in their judgements of valence for negative emotions, particularly anger, fear and disgust, although their intensity rating for emotion utterances was similar to controls. In contrast to the work of Breitenstein et al. (2001), executive function was not associated with prosody performance, despite the fact that the working memory

performance of PD patients was significantly worse than controls. Like the work of Pell and Leonard (2003), these results provide further evidence that emotion prosody is processed by a distinct neural substrate that involves the basal ganglia but does not engage areas of the brain responsible for higher level cognition. Additionally, the results implied that the basal ganglia use temporal information in recognising emotion prosody rather than semantic cues.

1.52 The role of the basal ganglia

Jacobs, Shuren, Bowers and Heilman (1995) examined participants with PD on tasks involving facial expression production, discrimination and imagery. They found that the performance of PD patients was significantly worse than controls on all three tasks. Interestingly, their performance was not related to motor severity or depression. Their findings suggested that there is a distinct neural substrate for the processing of facial emotions, which is separate from the processes controlling mood disturbances and the motor deficits of the disease.

Kan, Kawamura, Hasegawa, Mochizuki, and Nakamura (2002) investigated whether distinct neural substrates underpinned different modalities in emotion processing. They tested participants with PD and controls on emotion recognition tasks that involved facial expressions, emotion prosody, and written emotion statements. Participants with PD performed significantly worse than controls when recognising facial expressions of fear and disgust but not on prosodic or written stimuli. The findings suggested that the neural substrates responsible for recognising visual emotion may be different to those involved in processing vocal and verbal stimuli. An alternative explanation is that the PD group relied on semantic information, which

is processed in areas unaffected by PD, to recognise written emotion statements, and thus it could be argued that the same neural substrate processes emotion across different modalities.

The basal ganglia's role in emotion processing was investigated by Calder, Keane, Lawrence and Manes (2004). They tested participants with lesions to the ventral striatum on emotion recognition tests. In comparison to controls, participants with damage to the ventral striatum performed significantly worse in recognising facial expressions of disgust, fear, and anger, suggesting a role for the basal ganglia in the processing of negative emotions.

Calder, Keane, Manes, Antoun and Young (2000) examined the role of the basal ganglia in processing facial expressions of disgust in particular. They investigated a man with acquired lesions in his basal ganglia, involving specifically the putamen, and insula. He was impaired not only at recognising facial expressions of disgust, but also at recognising disgust in non-verbal emotion sounds and on tests of emotion prosody. Additionally, his experience of disgust was dampened when questioned about disgust provoking situations. In contrast, his semantic knowledge of disgust was intact (see also Kan et al., 2002). These findings suggested that the putamen and insula were involved in the processing of disgust across different modalities.

In contrast to the previous studies, Madeley et al. (1995) tested the ability of PD participants to pose and recognise a range of facial expressions. Although the PD group was significantly worse at posing facial expressions, they performed as did the controls on facial expression recognition. Adolphs, Schul, and Tranel (1998) also did

not find deficits among PD participants in emotion comprehension. When asked to rate the intensity of facial expressions, PD participants performed the same as controls. Despite evidence that the ventral striatum and putamen have been associated with deficits in emotion processing, they concluded that PD must affect areas of the basal ganglia, other than the ventral striatum or putamen, which are not necessary for recognising facial expressions.

Blonder, Gur and Gur (1989) compared participants with PD who had either right hemi-parkinson signs or left hemi-parkinson signs with controls on facial expression and emotion prosody recognition tasks. They found that both PD groups performed significantly worse on recognising emotion prosody and facial expressions than controls but were not different to each other. In contrast to the conclusions drawn by Adolphs et al. (1998), the results suggested that PD did affect areas of the basal ganglia responsible for emotion recognition, and the effects were bilateral. They compared their findings to the study of primates, in which the vocal utterances of monkeys are controlled by the limbic system, basal ganglia, and the thalamus. They suggested that emotion prosody in humans may represent a more primitive form of emotion communication reflected by its subcortical organisation.

Cheung, Lee, Yip, King and Li (2006) provided support for the basal ganglia's involvement in emotion processing. They tested patients who had left and right hemispheric subcortical stroke in the basal ganglia and thalamus. They found that participants with both left and right-sided strokes had emotion recognition deficits for anger, fear, and disgust.

Breitenstein, Daum and Ackermann (1998) examined whether subcortical and cortical structures contributed to emotion comprehension. They examined participants with PD, focal cortical lesions, and controls on tests of facial expression and emotion prosody discrimination and recognition. The PD participants were divided into two groups; one group was in the first disease stage with only unilateral symptoms while the second group was in the second disease stage with bilateral symptoms. Participants in the second PD stage and those with right frontal damage performed worse on recognising facial expressions and emotion prosody. In particular, anger and fear were more difficult to recognise than the other emotions. Disgust, however, was not included as an option. This evidence suggested that both cortical and subcortical, i.e. fronto-striatal, circuits are involved in emotion processing.

1.53 The role of dopamine in emotion processing

The effects of dopamine in processing anger, in particular, were investigated by administering a dopamine antagonist (sulpiride) to a group of healthy controls. When given an acute dose of sulpiride, participants showed impaired performance in recognising facial expressions of anger (Lawrence, Calder, McGowan, & Grasby, 2002). This finding suggested that reduced levels of dopamine due to PD have an effect on emotion comprehension in people with PD.

Lawrence, Goerendt, and Brooks (2007) tested PD patients who were acutely withdrawn from their medication. They examined the PD group's performance compared to controls on tests of facial expression recognition. Like the previous study, the PD group was impaired in the recognition of anger. Their findings further

supported the link between dopamine and deficits in the processing of facial expressions, particularly anger.

Sprengelmeyer et al. (2003) examined the role of dopamine in PD by testing a PD group in the early course of their disease and not yet on medication and a second PD group in the moderate phase of the disease and taking dopamine replacement therapy. They compared both groups to controls on facial expression recognition tests. Both PD groups showed impaired recognition of anger and fear compared to controls. However, the un-medicated group showed more pronounced deficits than the medicated group, particularly with respect to disgust. They concluded that the reduction of dopamine in the un-medicated PD group pointed to its role in the recognition of the facial expression of disgust.

Tessitore et al. (2002) tested PD participants on and off dopamine therapy on a facial expression discrimination task using fear and anger only. Functional imaging (fMRI) was conducted while the participants were performing the task. PD patients both on and off medication performed as well as controls on emotion discrimination. However, on imaging, control participants showed a robust bilateral amygdala response to fearful and angry faces, whereas the amygdala response was absent in the un-medicated group and was only partially restored in the medicated group. These findings indicated that the amygdala is involved in the perception of fear and anger and that the normal functioning of the amygdala is prevented in PD because of reduced dopamine. When dopamine levels are restored through medication, the activity of the amygdala is also partially restored. Further evidence of the effect of PD on the amygdala has been demonstrated in pathological studies showing atrophy

and lewy bodies in the amygdala of people who had PD (Cordato, Halliday, Harding, Hely, & Morris, 2000; Harding, Stimson, Henderson, & Halliday, 2002). It is interesting to note that the behavioural performance of both PD groups on the discrimination task was no different to controls. In support of Pell's (1996) hypothesis, these findings suggested that the discrimination task may be too easy to detect deficits between the groups. A complex task, such as an emotion recognition one, may have proved more difficult for PD participants.

1.54 Disease severity and duration

The measurement of disease severity in PD can differ depending on whether only the motor effects of the disease are taken into account or whether a broader definition is used that examines cognition, behaviour and mood among other things. Several studies have used the former measure and have found no significant association between disease severity and the performance of PD participants on emotion processing tasks (Dara et al., 2008; Dujardin et al., 2004; Jacobs et al., 1995; Suzuki, Hoshino, Shigemasu, & Kawamura, 2006). Other studies have found that disease severity did play a role in performance. Bowers et al. (2006) found that reduction in startle responses in PD, while watching aversive pictures, was significantly associated with disease severity.

The relationship between emotion comprehension and disease severity or duration is not always straightforward, however. Breitenstein et al. (2001) separated PD participants into early and moderate disease stage groups based on disease duration and found that the moderate group showed deficits in emotion comprehension while the early stage group did not. Despite these results, there were no significant

associations between emotion comprehension and disease severity as measured by the motor scale of the Unified Parkinson's Disease Rating Scale (UPDRS) for either of the two PD groups.

1.6 Social cognition

How might the deficits in recognising facial expressions and emotion prosody affect a person's ability to read and interact in social situations? Social cognition is a multi-faceted term involving, amongst other things, the ability to understand another person's mental state, a vital aspect of knowing how to behave in social circumstances. Researchers have developed a construct called "Theory of Mind" as a method for measuring social cognition in a more objective manner. Theory of Mind (TOM) refers to the ability to assign independent mental states to oneself and others in order to explain and predict another person's behaviour (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001; Gallagher et al., 2000).

Although TOM was originally developed to study the social cognition deficits in autism and the development of social reasoning in young children, it has been extended to other populations, such as people with PD. For instance, Saltzman, Strauss, Hunter, and Archibald (2000) examined TOM and executive function in a group of elderly adults, young adults, and participants with PD. They found that PD participants performed significantly worse than elderly controls on the overall TOM score. When looking at their performance on the four subtests that made up the overall TOM score, they performed more poorly than controls on two of the four subtests. They were not able to infer another person's false belief when reading a story and when planning a course of action in order to deceive another person. They

were able, however, to understand that one person may have a different interpretation than another when looking at a cartoon picture. They were also able to discover that the examiner was manipulating a hiding location for an object and that following the lead of the examiner ensured success. Significant associations were found between the performances of the PD participants on their TOM measures and on tasks of executive function, indicating that these constructs are related. Findings from this study suggested that PD affects some aspects of social cognition, but other aspects remain intact.

Mendelberg and Siegert (2003) studied PD participants on four TOM tasks, as well as tests of executive function, such as general reasoning and memory. The PD participants showed deficits on three of the four TOM tasks while they performed as well as controls on the executive function tasks. These results demonstrated a specific TOM deficit in participants with PD, distinct from executive function.

In his review on the neural bases of TOM, Sabbagh (2004) argued that TOM tasks require two distinct circuits, one that is responsible for decoding other's mental states, while the other is responsible for reasoning about other's mental states. He reasoned that the ability to decode another person's mental state requires being able to read facial expressions. Imaging studies that have tested normal subjects have found that the orbitofrontal and medial temporal areas in the right hemisphere are highly activated during a TOM task. Although Sabbagh (2004) was applying these findings to autism, they can also be applied to deficits in recognising facial expressions among PD patients and suggest that the orbitofrontal area, in addition to the amygdala, is essential to emotion processing. Rolls (2004) reasoned that both the orbitofrontal area

and its links to the striatum are critical in emotion processing. He theorised that the primary functions of the orbitofrontal cortex are to modulate reward value for salient stimuli and that damage to this area could impair face and voice expression recognition. This line of reasoning is particularly relevant in PD since the basal ganglia and its connections to frontal areas and the amygdala are primary sites of neuro-degeneration in this disease.

In an effort to bridge the inconsistencies in the literature over the significance of the amygdala's role vs. the fronto-striatal network's role in emotional processing of facial expressions and prosody, Adolphs (2002) argued that the amygdala may be involved in more passive or implicit processing of emotions. For instance, the perceptual processing of facial expressions of fear activated the amygdala. However, if a task required a person to *explicitly* label an emotion, the frontal-striatal network is activated, and the amygdala's response is reduced. The orbitofrontal cortex, as opposed to the amygdala, is involved in more active processing of emotions. He also noted that the amygdala's activation in emotional processing was more robust before adolescence and declined with age as frontal areas took over.

1.7 Cued autobiographical memory

It has been argued that autobiographical recall is facilitated by the use of emotional rather than neutral cues (Robinson, 1976). Cimino, Verfaellie, Bowers, and Heilman (1991) used the Crovitz cued autobiographical paradigm with emotion and non-emotion words on participants with right hemisphere damage. Since right hemisphere damage has been linked with deficits in emotion processing, they hypothesised that their recall would be impaired when cued with emotion words but not with neutral

words. They found that the recall of participants with right hemisphere damage was less specific and had less emotionality for both emotion and non-emotion words compared to controls.

Crucian et al. (2001) tested participants with PD using a similar method to the previous study. They chose eight non-emotion words that had previously been found to be neutral with regard to valence and arousal. The emotion words that they used, i.e. happy, sad, fear, and anger, were chosen based on their level of arousal and activation. Fear and anger constituted the high arousal/activation group while happy and sad were considered low arousal/activation. Since PD is associated with dampened affect in the production of facial expressions and prosody, one might expect their recall when cued by emotion words to be reduced. However, the authors argued that PD may cause a kinesia paradoxica, i.e. deficits in endogenously evoked activation occur in the presence of disinhibition in exogenously evoked activation. This phenomenon is displayed through the patient being able to perform rapid, energetic movements far more easily than slow ones. Therefore, the authors predicted that participants with PD would produce more recall when given external cues. They measured autobiographical recall by timing the duration of a participant's discourse and counting the total number of words used. They found that PD patients produced more words and spoke for a longer period with high activation emotion words, i.e. anger and fear, while their performance was the same as controls on low activation emotion words and non-emotion words.

1.8 Methodological factors

The question of whether and to what extent deficits in emotion processing exist in PD remains controversial. Some of the variability between studies can be attributed to methodological factors. For instance, the type of task used to measure emotion comprehension has varied greatly. Instead of standardised photographs or computer images of facial expressions, some studies have used cartoon drawings of facial expressions (Caekebeke, Jennekens-Schinkel, van der Linden, Buruma, & Roos, 1991). The different types of prosody measures have ranged from those that measure "pure" prosody without semantic content to those that convey emotion prosody in a sentence with the aid of semantic information. Other studies have used tasks in which the prosodic message is incongruent to the semantic one (Breitenstein et al., 2001). Benke et al. (1998) tested their participants on the ability to recognise a surprise element in humorous sketches.

Task difficulty is another variable that has varied widely. Some researchers have used the standardised set of Ekman and Friesen (1976) photographs with their prototypical facial expressions, but it may be that these photographs are easy to decipher resulting in a ceiling effect. Additionally, the photographs do not represent facial expressions as seen in everyday life. Ordinary facial expressions are more subtle and often blended while the Ekman and Friesen (1976) photographs are aimed at non-ambiguity. Dujardin et al. (2004) digitally manipulated prototypical facial expressions to create a range of intensities. Participants with PD compared to controls were significantly less accurate in recognising facial expressions of both high and low intensities across all three emotions of anger, sadness and disgust. Suzuki et al. (2006) blended the six basic emotions, two at a time, into morphed images that were

less intense facial expressions and compared them with the Ekman and Friesen (1976) series. PD participants showed a specific deficit in the recognition of disgust compared to controls when tested on blended facial expressions, but no differences were found when tested on prototypical photographs.

1.9 Aims and hypotheses

Based on the review of the literature, the current study aimed to extend the existing body of knowledge concerning the breath of emotion processing deficits in PD by measuring one patient group across a broad range of skills. No previous study of PD patients has used the comprehensive range of emotion processing tests that were incorporated into the current study. The test battery included visual emotion recognition, auditory emotion discrimination and recognition, emotional imagery, emotion vignettes, and emotionally-laden images. Since previous research has found that task complexity is a factor in the performance of PD participants, the study design incorporated tests measuring both lower level and complex emotion processing skills.

In addition to measuring emotion processing, the current study aimed to replicate previous findings regarding social cognition and autobiographical memory in the PD population. Comparisons were made with a control group matched for age, gender, and estimated premorbid intelligence.

Based on previous evidence from research, the following hypotheses were formulated:

i) Participants with PD would perform as well as controls on facial expression recognition tasks, which involved prototypical photographs of facial expressions. In contrast, they would perform significantly worse when asked to recognise morphed computer images of facial expressions with low and high intensities.

ii) Performance on tasks of propositional and emotion prosody discrimination would not differ between controls and participants with PD; however, the PD group would show deficits in emotion prosody recognition and on tasks in which the semantic message is incongruent to the prosodic one.

iii) With the aid of semantic information, the participants with PD would be able to choose the correct emotion label as well as controls when reading emotion vignettes.

iv) Participants with PD would be significantly worse at imagining the facial components of particular emotions compared to controls.

v) While viewing emotionally-laden pictures, participants with PD would show reduced sensitivity in their arousal ratings but not in their ratings of valence compared to controls.

vi) PD participants would show deficits in social cognition compared to controls, i.e. they would not be able to infer a false belief held by another person as well as controls. Secondly, their performance would be significantly worse than controls at judging what another person was feeling by looking at computer images of the person's eyes.

vii) Findings from the Crucian et al.(2001) study, in which participants with PD displayed verbal kinesia paradoxica when recollecting autobiographical events associated with emotion and non-emotion words, would be replicated.

viii) The profile of deficits in emotion comprehension will shed light on the neural substrates involved in emotion processing and damaged by PD.

ix) Deficits in emotion processing among participants with PD would not be significantly associated with disease factors or mood disturbances.

CHAPTER 2: METHODS

2.1 Participants

Sixteen volunteers (12 men and 4 women) with a mean age of 61 years, ranging from 52 – 74 years, participated in the PD group. Participants were recruited from the Movement Disorder Clinic, an outpatient clinic at Westmead hospital. All of the participants had been diagnosed with Parkinson's disease by an experienced neurologist. Their illness duration ranged from one year – seventeen years. The severity of the participants' motor symptoms ranged broadly from mild – severe, corresponding with stages I – IV of the Hoehn-Yahr Scale (1967), which categorises motor symptoms in Parkinson's disease.

All participants, with the exception of one, were being treated with levodopa or a dopamine agonist medication. See Table 2-2 below for a complete list of current PD medications being taken by participants with PD. One participant who was not on dopamine replacement therapy was in the early stages of Parkinson disease (duration 2 years) and was being treated with Trihexyphenidyl, an antispasmodic drug.

Participants with dementia or other neurological disorders such as stroke, head injury, epilepsy, major psychiatric history such as schizophrenia, or a history of chronic substance abuse, were excluded from the study. The Addenbrooke's Cognitive Examination Revised (ACE-R) was given to determine whether participants met criteria for dementia. All participants scored well above the dementia cutoff score of 24 for the Mini Mental Status Examination (scores ranged from 28 - 30) and 83 for the ACE-R (scores ranged from 86 - 100).

Three participants, two males and one female, had undergone Deep Brain Stimulation (DBS) surgery. Reasons for surgery were varied. One participant had severe problems with dyskinesia and underwent surgery seven years after being diagnosed with PD. A second participant had surgery thirteen years post diagnosis with PD because of his inability to initiate action. The third participant had surgery sixteen years after her diagnosis because of problems with rigidity and walking. Evidence suggests that the effects on motor symptoms, mood, and cognition as a result of DBS are similar to the effects of dopamine replacement therapy. Current research has found no effects or a slight improvement in cognition along with enhanced mood after DBS surgery (Castelli et al., 2006; Patel et al., 2003; Pillon et al., 2000). Participants were tested during the stimulation "on" phase.

Sixteen healthy control volunteers (12 men and four women) with a mean age of 62 years, ranging from 54 – 74 years, were chosen to match the PD participants as closely as possible with respect to age, premorbid intelligence and gender. Their premorbid intelligence was estimated using the National Adult Reading Test (NART;Nelson, 1991). They had no history of neurological or major psychiatric illness. All participants gave informed consent to participate in the study. The characteristics of the PD group and the control group are given in Table 2-1 on the following page.

Table 2-1
Demographic characteristics of the participant groups

Group	**PD Group Mean (SD)**	**Control Group Mean (SD)**
Sex: Male/Female	12/4	12/4
Age in years	61.19 (5.12)	62.38 (5.43)
Years of Education	14.56 (3.12)	15.19 (2.74)
Estimated Premorbid IQ - NART	112.80 (11.43)	112.44 (9.22)
MMSE ACE-R	29.50 (0.97) 93.44 (4.79)	29.75 (0.45) 96.44 (2.48)
Duration of illness (years)	9.94 (5.20)	
Severity of illness Hoehn-Yahr Scale (stages I – IV)	3.19 (0.66)	

Table 2-2
Type of Medication for PD participants

PD Medication	**No.**
Levodopa/Carbidopa	11
Levodopa only	2
Dopamine Agonists	5
Anticholinergics	1
Amantadine	2
Combinations (taking >1 PD drug)	10

2.2 Stimuli

2.21 Facial expressions of emotion

Twenty-four photographs of facial expressions from the Ekman & Friesen series were chosen for the study (Ekman & Friesen, 1976). Four photographs for each of the six emotions, happy, sad, anger, fear, disgust, and surprise, were selected; both male and female expressions were used. Based on the results of the Ekman and Friesen (1976)

study, photographs were chosen that were identified at a greater than 80% success rate by a control population. Six emotion labels were placed in front of the participant while they viewed each photograph, one at a time. The participant was asked to name the emotion that best expressed what the person in the photo was feeling. Responses were not timed. The photographs were placed in random order, and this order was kept constant across all of the participants.

Sixty images from the Montreal Set of Facial Displays of Emotion (MSFDE), a series of facial expressions constructed by Beaupré and Hess (2005), were used to display facial expressions with less intensity than the prototypical photographs of Ekman and Friesen (1976). The set consisted of facial expressions by men and women of European, Asian, and African descent. Each expression was created using a directed facial action task and all expressions were coded to assure identical expressions across actors. Facial expressions of happiness, sadness, anger, fear, disgust, embarrassment, and neutral are displayed by each actor. Each expression was morphed into six different levels of intensity with 100%, reflecting a prototypical facial expression and 0% reflecting a neutral face, (100, 80, 60, 40, 20, and 0).

For the purpose of this study, the images included five emotions (happy, anger, sad, fear, and disgust), two levels of intensity (40 and 80), three different cultural backgrounds (European, Asian, and African) and two genders (male and female). Embarrassment was excluded as it was not considered to be a primary emotion. Two levels of intensity were chosen to form high (80%) and low (40%) level conditions. Based on a cross-cultural study by Beaupré and Hess (2005), in which they used the

MSFDE and found no in-group cultural bias for recognising facial expressions, expressions from all three cultures were chosen for this study.

Five emotion labels were placed in front of the participant while the sixty facial expressions were displayed on a computer screen one at a time. Participants were asked to choose a label that best described how the person in the photo was feeling. Although the task was not timed, participants were asked not to spend too much time thinking about the expressions but to choose the emotion that first came to mind when looking at the computer image.

Participants were not tested on face recognition since previous studies have not found deficits in performance on face identification tasks among participants with PD (Adolphs et al., 1998; Dujardin et al., 2004; Lawrence et al., 2007; Sprengelmeyer et al., 2003; Suzuki et al., 2006).

Individual items were scored by their emotion label for both the Ekman facial expressions and the MSFDE. Each emotion was assigned the same number for both tests: happy = 1, anger = 2, sad = 3, fear = 4, disgust = 5 and surprise = 6. The MSFDE test did not have surprise as a choice, however. Accuracy scores for each emotion were computed by adding the number of items correct. In addition to emotion accuracy scores, an overall score for each test was computed.

Further scoring was undertaken on the MSFDE task. Items were separated into low and high intensity, and accuracy scores were computed for each emotion under the two types of intensity.

2.22 Emotion prosody

Four tasks from the Florida Affect Battery - revised (FAB-r), measuring different aspects of prosody, were selected (Bowers, Blonder, & Heilman, 1991). The non-emotion prosody discrimination task was chosen to assess the participant's ability to discriminate between two different types of propositional prosody, i.e. interrogative and declarative. During the test, the participant was asked to listen to 16 pairs of sentences that were either spoken as a statement or a question. Eight sentences were spoken in the same tone of voice, i.e. both were said as questions or both were said as statements. The remaining eight sentences were spoken with different propositional prosody. For example, one was a question while the other was a statement.

The second task involved emotion prosody discrimination. Twenty pairs of sentences were spoken in the same or different tones of emotion. Half of the sentences were said in the same emotional tone and half were spoken in different tones. Semantic content in all of the sentences was neutral, i.e. "the boy is going to the store."

The third task required the participants to name the emotion prosody conveyed in the sentence. Twenty semantically neutral sentences were spoken in one of four different emotional tones or in a neutral tone (four of each): happy, angry, sad, frightened, and neutral.

The last prosody task involved asking participants to name the emotion prosody conveyed in 36 sentences. In one-half of the trials, the semantic content and the prosody conflicted. For example, "All the puppies are dead" in a happy tone of voice. In the other half of the sentences, the semantic and prosodic messages were

congruent. For instance, "All the puppies are dead" in a sad tone of voice. Before the task began, the participants were asked to ignore the semantic content of the sentence and instead, to focus on the prosodic message (Bowers, Blonder, & Heilman, 1991).

Scoring for the FAB-r non-emotion and emotion discrimination tests were computed by assigning a "0" for an incorrect answer and a "1" for a correct answer. A total accuracy score was then obtained for each test by adding the number of items correct.

Scoring for the naming and conflicting prosody tasks followed a similar procedure to the facial expression recognition tests. Each emotion was assigned the same number for both tests: happy = 1, anger = 2, sad = 3, and fear = 4. Since neither of these tests had disgust or surprise as choices, neutral was assigned the number five. Accuracy scores for each emotion were computed by adding the number of items correct. An overall score for each test was also computed.

2.23 Emotion vignettes and imagery

The Emotion Vignettes task was one of two measures designed specifically for this study. It was based on tasks used in developmental psychology concerning knowledge of emotion and the learning of display rules in children (Bennett & Knight, 1996; Garner, 1999; Jones, Abbey, & Cumberland, 1998). Each item contained a short story in which a particular emotion is intended to be felt by the main character through the events of the story. The task featured six emotions, i.e. happy, angry, sad, frightened, disgusted and surprised, depicted in eight stories and comprising 48 items in total. After reading each story, the participant was required to

circle the emotion label that best described how the main character of the story was feeling.

The second measure developed for this study was the Imagery of Emotion task. It was based on a similar measure by Bowers, Blonder, Feinberg, and Heilman (1991). However, the questions were adapted to convey more recognisable facial movements based on a componential approach to facial expressions (Ekman & Friesen, 1978; Gosselin, Kirouac, & Dore, 1992; C. A. Smith & Scott, 1997). The task required participants to imagine the facial components of six emotions, i.e. happiness, sadness, anger, fear, disgust, surprise, and answer the same eight yes/no questions for each emotion. While imagining a particular emotion, participants were asked questions such as "Is the upper lip raised?" Or, "Are the eyebrows raised?"

Both measures were validated in a pilot study using 22 first year, undergraduate psychology students from the University of Sydney, undertaken to determine whether the items on each test were indeed conveying the particular emotion that was anticipated by the author. Those items that were not scored accurately by 50% or more of the students were eliminated from the measures. This figure was based on a study by Pell (2002), in which facial expression and emotion prosody measures were validated using similar criteria.

Following the pilot study, six items were eliminated from the emotion vignettes test because more than 50% of the participants did not choose the intended emotion label. Four items for surprise, one for anger, and one for disgust were eliminated from the

task. Forty-two items remained, leaving eight vignettes each for happiness, sadness, and fear, seven vignettes each for disgust and anger, and four vignettes for surprise. Thirteen items were eliminated from the imagery of emotion task when more than 50% of the participants answered them incorrectly. Thirty-five items remained on the test, five each for happiness, fear, and disgust, six for sadness, and seven each for anger and surprise. Refer to Appendices 1 and 2 for copies of the emotion vignettes and the imagery of emotion questionnaires, respectively.

Scoring for the emotion vignettes task followed a similar procedure to the facial expression recognition tasks; each emotion was assigned the same number. *Percent* accuracy scores were obtained since the number of items per emotion was not consistent across the test. This method enabled comparisons to be made across emotions within the task. An overall score for the test was computed as well.

Scores for the imagery of emotion task were computed by assigning a "0" for an incorrect answer and a "1" for a correct answer. A total accuracy score was obtained by adding the number of items correct. Since the number of items per emotion was not consistent, a percent accuracy score was obtained by emotion.

2.24 Social cognition

Two measures, a TOM cartoon task and "Reading the Mind in the Eyes" revised test, were used to measure social cognition. The cartoon task consisted of ten TOM and ten non-TOM pictures that were displayed on a computer screen. A cartoon was classified as TOM if the humour depended upon a character having a mistaken thought or belief about one or more of the characters in the picture. The humour in

the non-TOM cartoons did not involve a character's false belief but instead involved a physical anomaly or violation of a social norm (Happe, Brownell, & Winner, 1999). The Happe et al. (1999) scoring method was used for the TOM test. Items were scored from 0-3, with '3' representing a full explanation including a reference to a mistaken thought or belief for the TOM cartoon, whereas a '3' on non-TOM cartoons was given for a full and explicit explanation involving a physical anomaly or violation of a social norm. Refer to Appendix 3 for a complete explanation of the scoring method. Total scores were computed for the TOM and non-TOM cartoons separately. In addition to the author of this paper, a second rater who was blind to subject and hypothesis scored the TOM and non-TOM cartoons. Good inter-rater reliability was reached as the intraclass correlation coefficient was 0.84.

Sixteen computer images of the original 36 from the "Reading the Mind in the Eyes" revised test were used in this study (Baron-Cohen et al., 2001). The images showed pairs of eyes from males and females but did not include any other facial features. With each pair of eyes, the participant was asked to choose which word (out of four choices) best described what the person in the photograph was thinking or feeling. The photographs depicted complex emotional states in which an attribution of a belief or intention was required. Consequently, the word choices given to label the photographs described more complex feelings. For example, some choices were suspicious, defiant, preoccupied, thoughtful etc. A glossary was provided in case a participant did not understand the meaning of a given word.

Scores for the "Reading the Mind in the Eyes" task were computed by assigning a "0" for an incorrect answer and a "1" for a correct answer. A total accuracy score was obtained by adding the number of items correct.

2.25 Pictures of emotion

The International Affective Picture System (IAPS) is a standardized and normed set of over 900 affective pictures rated along three dimensions: valence, arousal and dominance (Lang, Bradley, & Cuthbert, 2001a). For the purpose of this study, thirty pictures were chosen according to their ratings on the valence and arousal dimensions only. The third dimension of dominance was not used in the rating procedure since it has been found to be less reliable than the other two dimensions (Lang, Bradley, & Cuthbert, 2005). Based on previous normative studies, pictures were chosen that had been rated at the extreme ends of the valence spectrum, half had high pleasantness ratings while the other half had been rated as highly unpleasant. All of the pictures chosen had high arousal (intensity) ratings. The content of the unpleasant pictures included war, physical violence, starvation, etc. (IAPS no's: 1050, 2095, 2683, 2455, 2688, 2710, 2900, 6020, 6212, 6350, 6370, 6838, 7380, 9040, & 9300). Pleasant pictures included images of a porpoise, a baby smiling, happy families, etc. (IAPS no's: 1440, 1811, 1920, 2058, 2154, 2209, 2340, 4610, 5470, 5833, 5910, 7325, 8179, 8370, & 8380).

The paper version of the Self-Assessment Manikin (SAM) affective rating system was used; it is a 1-9 Likert scale. The valence scale ranged from a graphic figure, displaying a very happy image, at one end of the scale (9) to a figure, portraying a very sad image, at the other end of the scale (1). The arousal scale depicted a very

excitable figure at on end of the scale (9) and a very calm figure at the opposite end of the scale (1;Lang et al., 2005). The pictures were displayed on the computer screen, one at a time, and participants were asked to rate each image according to how it made them feel along the two dimensions – happy/unhappy and excited/calm. Responses were not timed.

Raw scores were summed by grouping items into categories according to low valence, high valence, and arousal. Percent accuracy scores were then obtained for each category.

2.26 Cued autobiographical memory

Based on the Crovitz paradigm (Crovitz & Schiffman, 1974), participants were asked to recall an autobiographical memory from their childhood or young adulthood (distant past) relating to a particular word. Eight words were used: four emotion words and four non-emotion words. The emotion words were happy, anger, fear, and disgust while the non-emotion words were: lamp, key, juice, and shirt. The control words were selected based on their neutrality with respect to emotional arousal (Crucian et al., 2001). Participants were shown one word at a time, allowed to respond freely, and their responses were tape recorded. The taped responses were then transcribed verbatim.

Scores were obtained for each cued response by adding up the total number of words used and timing the length of discourse (in seconds). Scores were then summed to obtain an overall total word count and discourse length for the emotion words and overall measures for the non-emotion words.

2.27 Mood

The short-form version of the Depression, Anxiety and Stress Scale (DASS-21) was administered to measure participants' mood levels over the week preceding their assessment (Lovibond & Lovibond, 1995). Standard scoring procedures were used for the DASS-21.

2.3 Procedure

Ethics approval was granted by the Human Research Ethics Committee of the Sydney West Area Health Service, which oversees the operations of Westmead Hospital and the University of Sydney. Assessments lasted approximately three hours. All patients were tested in their home with a carer present. The first 20 minutes of the assessment involved an interview in which voluntary consent forms were signed; demographic information was obtained; and detailed information regarding primary symptoms, duration, and severity of their PD was noted. PD medications were also recorded. The interview was followed by two and a half hours of neuropsychological testing. One or two breaks were taken as requested. Refer to Appendix 4 for a copy of the patient information and consent form.

2.4 Data Analyses

Statistical analyses were conducted using SPSS for Windows 15.0 (SPSS, 2006).

2.41 Group comparisons

Repeated measures analyses of variance (ANOVA) was conducted for each emotion recognition test with type of emotion as the within-subject factor and group as the between-subjects factor. Pairwise comparisons were performed to analyse the

differences between groups for each emotion. Additional repeated measures analyses were performed for the cued autobiographical memory test and the IAPS task. Within-subject factors were discussion length and word count for the autobiographical task. For the IAPS task, within-subject variables were arousal and low/high valence. Group was the between-subjects factor for both analyses. Pairwise comparisons were performed to examine differences between groups for discussion length and total word count on the autobiographical memory task, and for arousal and low/high valence on the IAPS task.

One way between-subjects ANOVAs were performed on the FAB-r non-emotion and emotion prosody discrimination tasks, the TOM task, and the "Reading the Mind in the Eyes" task. Total scores for each test functioned as the dependent variables while the PD and control groups were the independent variable. Dependent measures were total number correct for the prosody tasks and overall total score for the social cognition tests. One way between-subjects ANOVAs were also conducted for the DASS mood inventory and for the control variables, i.e. age, education, and NART score.

2.42 Correlations

Pearson product-moment correlation coefficients for the PD group were calculated to determine the relationship between mood and disease variables, i.e. disease length and severity, and performance on the experimental tasks of emotion discrimination and recognition, social cognition, and autobiographical memory.

CHAPTER 3: RESULTS

3.1 Demographic Statistics

Thirty-two participants were included in the study with sixteen in each group. There were no significant differences in age, $F(1, 31) = 0.41$, $p = 0.53$, education, $F(1, 31) = 0.36$, $p = 0.55$), and estimates of pre-morbid intelligence, $F(1, 30) = 0.01$, $p = 0.92$, between the two groups. See Table 2-1 for the demographic characteristics of the participants.

Mood was assessed using the shortened version of the DASS. The difference between the PD and control groups in their levels of depression was significant, $F(1, 31) = 5.16$, $p = 0.03$, as the PD group scored in the mildly depressed range while controls were found to be in the normal range. Refer to Figure 3-1 below and Table 3-1 on the following page. There were also significant differences in anxiety levels between the two groups as the PD group was found to be moderately anxious while the controls scored in the normal range, $F(1, 31) = 29.46$, $p < 0.01$. Both groups were found to have normal levels of stress and were not significantly different from each other, $F(1, 31) = 1.74$, $p = 0.20$.

Figure 3-1
Mean Levels of Depression, Anxiety and Stress for PD and Control Participants

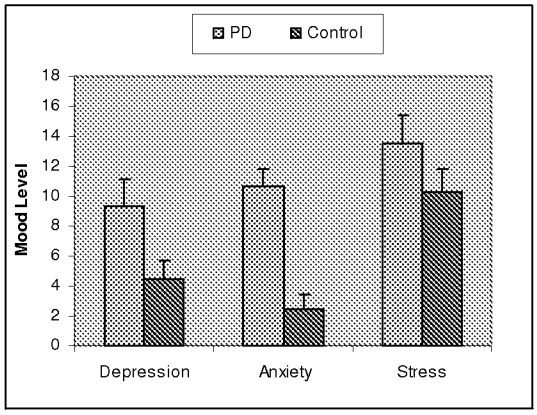


Table 3-1
Group Means for Mood Levels

Mood	PD Group[a] *M (SD)*	Controls[a] *M (SD)*	*F (1, 31)*
Depression	9.38 (7.14)	4.50 (4.76)	5.16
Anxiety	10.63 (4.72)	2.50 (3.69)	29.46*
Stress	13.50 (7.68)	10.25 (6.19)	1.74

[a] $n = 16$ for each group
*$p < .01$.

Repeated measures ANOVAs were conducted for the emotion recognition measures. Emotion served as the within subjects factor while the PD and controls groups served as the between subjects variable. The main effect of interest was the difference in recognition between the two groups. The interaction between the group and emotion was also of interest and therefore, pairwise comparisons between the two groups for each emotion were discussed. Main effects of emotion were not considered relevant to the study and have not been covered in the results section.

Due to the large number of dependent measures and consequent analyses performed, a significance level of 1% was adopted from this point forward. The aim in using such a stringent significance level was to reduce the likelihood of type I errors due to running multiple comparisons.

Effect sizes for independent samples (the PD and control groups) were estimated for each emotion within a task on the emotion recognition measures, and for each of the dependent variables in the social cognition, IAPS, and autobiographical memory tasks (Rosenthal & Rosnow, 1991).

3.2 Facial Expressions

Recognition of facial expressions was measured using Ekman & Friesen (1976) photographs, and computer images of the MSFDE. The dependent measure for both tests was number correct. It was predicted that the PD group would recognise facial expressions as well as controls on the Ekman task. No significant main effect of group was found, $F(1, 30) = 0.27$, $p = 0.61$. Refer to Table 3-2 below. In pairwise comparisons, the PD group performed as well as controls in recognising each of the six emotions, all $p \geq 0.02$.

Table 3-2
Ekman: PD and Control Group Means for Emotion Recognition

Emotion	PD Group[a] *M (SD)*	Controls[a] *M (SD)*	*D*
Happy	4.00 (0)	4.00 (0)	0
Anger	2.81 (0.66)	3.18 (0.75)	0.55
Sad	3.31 (0.87)	2.50 (1.03)	- 0.88
Fear	2.19 (1.11)	1.69 (1.01)	- 0.49
Disgust	3.44 (0.89)	3.88 (0.34)	0.67
Surprise	3.69 (0.48)	3.81 (0.40)	0.29

Note. The total possible score for each emotion is 4.
d = standardised mean difference. The differences were not significant at the 0.01 level.
[a] $n = 16$ for each group

It was predicted that the PD group would not recognise facial expressions from the MSFDE as well as controls. In fact, there was no significant overall difference between the two groups in recognising facial expressions on the MSFDE, $F(1, 30) = 0.61$, $p = 0.44$. Refer to Table 3-3 on the following page. When making pairwise comparisons, the PD group was able to recognise each of the five emotions as well as controls, all $p > .03$.

Table 3-3

MSFDE: Group Means for Emotion Recognition

Emotion	PD Group[a] *M (SD)*	Controls[a] *M (SD)*	*d*
Happy	10.13 (0.72)	9.75 (1.13)	- 0.41
Anger	6.88 (2.25)	6.56 (2.13)	- 0.15
Sad	7.44 (1.97)	7.81 (2.07)	0.19
Fear	5.69 (2.36)	5.88 (2.36)	0.08
Disgust	5.94 (1.75)	7.50 (1.75)	0.85

Note. The total possible score for each emotion is 12.
d = standardised mean difference. The differences were not significant at the 0.01 level.
[a] *n* = 16 for each group

Facial expressions of low and high intensity on the MSFDE task were examined separately. There was no significant overall difference between the PD and control group when recognising facial expressions of low intensity, $F(1, 30) = 0.20$, $p = 0.66$, and no difference in performance between the two groups for each emotion, all $p > 0.10$. Refer to Table 3-4 below.

Table 3-4
MSFDE: Groups Means in Emotion Recognition for Facial Expressions of Low Intensity

Emotion	PD Group[a] *M (SD)*	Controls[a] *M (SD)*	*D*
Happy	4.13 (0.72)	3.75 (1.13)	- 0.41
Anger	2.63 (0.96)	2.56 (1.03)	- 0.07
Sad	3.56 (1.36)	3.44 (1.36)	- 0.09
Fear	2.06 (1.34)	2.38 (1.31)	0.24
Disgust	1.44 (1.09)	2.19 (1.38)	0.62

Note. The total possible score for each emotion is 6.
d = standardised mean difference. The differences were not significant at the 0.01 level.
[a] *n* = 16 for each group

Likewise, there was no significant overall difference between the two groups in recognition accuracy of high intensity facial expressions, $F(1, 30) = 0.64$, $p = 0.43$, and no significant differences for each of the five emotions, all $p > 0.08$. Refer to Table 3-5 below.

Table 3-5
MSFDE: Group Means in Emotion Recognition for Facial Expressions of High Intensity

Emotion	PD Group[a] *M (SD)*	Controls[a] *M (SD)*	*d*
Happy	6.00 (0)	6.00 (0)	0
Anger	4.25 (1.57)	4.00 (1.51)	- 0.17
Sad	3.88 (1.45)	4.38 (1.20)	0.39
Fear	3.63 (1.71)	3.50 (1.71)	- 0.08
Disgust	4.50 (1.41)	5.31 (1.14)	0.65

Note. The total possible score for each emotion is 6.
d = standardised mean difference. The differences were not significant at the 0.01 level.
[a] *n* = 16 for each group

3.3 Prosody measures

One test of propositional prosody and three measures of emotion prosody were used from the FAB-r battery. On the four prosody tasks, overall accuracy scores were obtained by adding the total number correct. Accuracy scores by emotion were also obtained for the two recognition measures.

It was predicted that the PD group would be able to discriminate propositional prosody as well as controls, and there was no significant difference between the groups in discriminating between declarative and interrogative prosody, $F(1, 31) = 0.01$, $p = 0.94$. Refer to Table 3-6 on the following page.

Table 3-6
FAB: Group Means for Non-Emotion and Emotion Prosody Discrimination

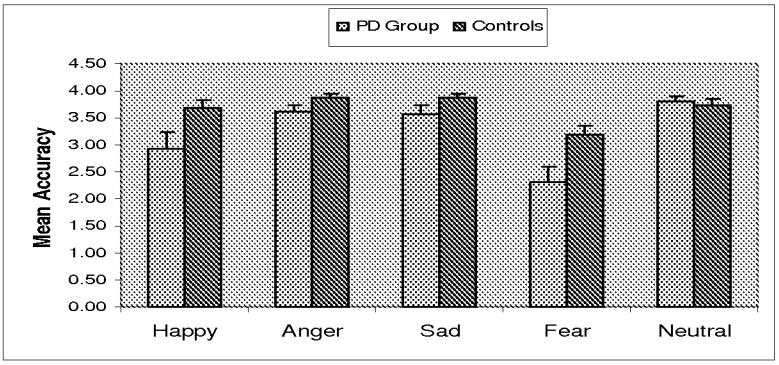
Prosody	PD Group[a] *M (SD)*	Controls[a] *M (SD)*	*D*
Non-Emotion	13.63 (2.19)	13.69 (2.12)	0.03
Emotion	19.38 (0.89)	19.88 (0.34)	0.75

[a] $n = 16$ for each group
d = standardised mean difference. The differences were not significant at the 0.01 level.

It was predicted that the PD group would be no different to controls when discriminating emotion prosody, and again when given happy, angry, sad, frightened or neutral tones as choices, no significant differences were found between the two groups in discriminating between these emotions, $F(1, 30) = 4.44$, $p = 0.04$. Refer to Table 3-6 above.

Differences between the two groups were, however, anticipated on emotion prosody recognition measures. As predicted, the PD group was significantly worse than the controls in recognising emotion prosody, $F(1, 30) = 8.55$, $p = 0.007$. Refer to Figure 3-2 and Table 3-7 on the following page. The PD group was less accurate, specifically, in recognising fear compared to the controls with the difference between groups just reaching the significance level, $t(30) = 2.67$, $p = 0.01$. The two groups did not differ in their recognition of happiness, anger, sadness, or neutral prosody, all $p \geq 0.04$.

Figure 3-2
FAB: Mean Accuracy Scores for Emotion Prosody Recognition



Note. Total possible score is 4.

Table 3-7
FAB: Group Means in Emotion Prosody Recognition

Emotion	PD Group[a] *M (SD)*	Controls[a] *M (SD)*	*d*
Happy	2.94 (1.24)	3.69 (0.60)	0.80
Anger	3.63 (0.50)	3.88 (0.34)	0.60
Sad	3.56 (0.73)	3.88 (0.34)	0.57
Fear	2.31 (1.14)	3.19 (0.66)	0.97*
Neutral	3.81 (0.40)	3.75 (0.45)	- 0.15

Note. d = standardised mean difference.
[a] n = 16 for each group
*p = .01.

On the conflicting prosody task, it was predicted that the PD group would recognise emotions as well as controls when the semantic and prosodic messages were the same, but that the PD group would perform less well when the messages differed. Congruent and incongruent items were analysed separately. There was indeed no significant overall difference between groups when the prosodic and semantic messages were congruent, $F(1, 30) = 0.37$, $p < 0.55$. Refer to Table 3-8 on the following page. The PD group performed as well as controls for each of the four tones, all $p \geq 0.02$.

Table 3-8
FAB: Group Means for Congruent Items in Conflicting Emotion Prosody Recognition

Emotion	PD Group[a] *M (SD)*	Controls[a] *M (SD)*	*d*
Happy[b]	3.00 (0)	2.63 (0.62)	- 0.88
Anger[b]	2.69 (0.48)	2.69 (0.48)	0
Sad[c]	4.31 (0.95)	4.88 (0.34)	0.82
Neutral[b]	2.94 (0.25)	2.94 (0.25)	0

Note. d = standardised mean difference. The differences were not significant at the 0.01 level.
[a] n = 16 for each group. [b] Number of items = 3. [c] Number of items = 5.

When the semantic and prosodic messages were incongruent, a significant overall difference was found between groups, $F(1, 30) = 12.96$, $p = 0.001$. Refer to Figure 3-3 below and Table 3-9 on the following page. The PD group was significantly worse at recognising anger, $t(30) = 3.12$, $p = 0.004$ and at recognising neutral tones, in which the difference just reached significance, $t(30) = 2.69$, $p = 0.01$. Their errors consisted, primarily, of confusing anger with neutral tones and neutral with sad tones. There were no significant differences between the two groups for happiness or sadness, all $p \geq 0.02$.

Figure 3-3
FAB: Percent Accuracy on Incongruent Items for Conflicting Emotion Prosody

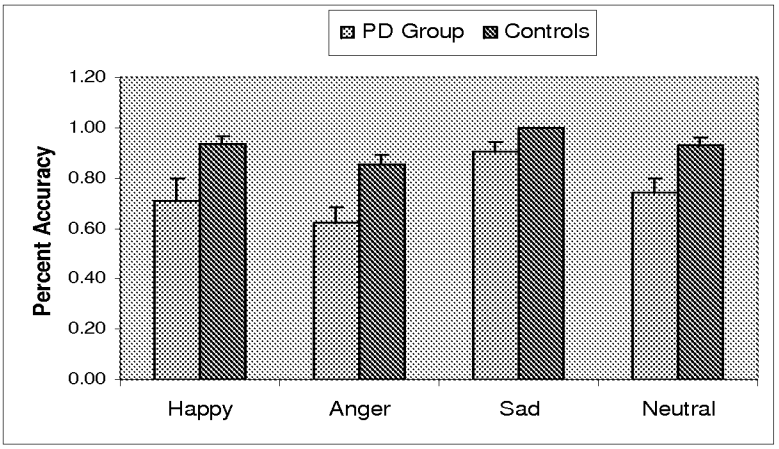


Table 3-9
FAB: Percent Accuracy for Incongruent Items on Conflicting Emotion Prosody Recognition

Emotion	PD Group[a] *% Acc (St Err)*	Controls[a] *% Acc (St Err)*	*d*
Happy[b]	0.71 (.09)	0.94 (.03)	0.88
Anger[b]	0.63 (.06)	0.85 (.04)	1.14**
Sad[c]	0.91 (.04)	1.00 (0)	0.88
Neutral[b]	0.74 (.06)	0.93 (.03)	0.98*

Note. d = standardised mean difference.
[a] n = 16 for each group.
*p = .01. **p < .01.

3.4 Emotion vignettes and imagery

It was predicted that there would be no differences between the groups in identifying the emotion felt by the main character of the story. The dependent measure for the emotion vignettes task was accuracy, and overall, there was no significant difference between the PD and control groups, $F(1, 30) = 1.76$, $p = 0.19$. Refer to Table 3-10 below. The PD group was able to identify each of the six emotions depicted in the vignettes as well as the control group, all $p > 0.25$.

Table 3-10
Vignettes: Group Means for Written Emotion Recognition

Emotion	PD Group[a] *M (SD)*	Controls[a] *M (SD)*	*d*
Happy[b]	7.81 (0.40)	7.81 (0.40)	0
Anger[c]	4.88 (1.41)	5.19 (1.28)	0.24
Sad[b]	6.38 (1.41)	6.88 (0.96)	0.43
Fear[b]	7.75 (0.45)	7.75 (0.58)	0
Disgust[c]	6.06 (1.34)	6.25 (1.29)	0.15
Surprise[d]	3.19 (0.66)	3.38 (0.62)	0.31

Note. d = standardised mean difference. The differences were not significant at the .01 level.
[a] n = 16 for each group. [b] Number of items = 8. [c] Number of items = 7.
[d] Number of items = 4.

It was anticipated that the PD group would be significantly worse on the imagery of emotion test. The dependent measures for this task were total number correct per emotion and overall. In contrast to predictions, there was no significant overall difference between the PD and the control group when imagining facial expressions, $F(1, 30) = 2.15$, $p > 0.15$, and no difference between groups on any individual emotion. Refer to Table 3-11 below.

Table 3-11
Imagery: Group Means for Imagery of Emotion

Emotion	PD Group[a] *M (SD)*	Controls[a] *M (SD)*	*d*
Happy[b]	4.50 (1.10)	4.56 (0.81)	0.07
Anger[c]	4.56 (1.37)	5.19 (1.17)	0.51
Sad[d]	5.38 (0.96)	5.50 (0.63)	0.16
Fear[b]	3.50 (1.41)	4.31 (0.79)	0.73
Disgust[b]	4.13 (0.96)	4.19 (0.83)	0.07
Surprise[c]	5.75 (1.18)	5.69 (1.01)	- 0.06

Note. d = standardised mean difference. The differences were not significant at the .01 level.
[a] $n = 16$ for each group. [b] Number of items = 5. [c] Number of items = 7.
[d] Number of items = 6.

3.5 Pictures of emotion

It was predicted that the PD group would show reduced sensitivity in their arousal ratings but not in their valence ratings compared to controls. There were no significant overall differences between the two groups in their ratings of either valence or arousal while viewing affective pictures, $F(1, 30) = 0.35$, $p = 0.56$. Refer to Table 3-12 on the following page. The PD group did not differ from the control group in their valence ratings of pictures that were highly unpleasant, $p = 0.44$ or

highly pleasant, $p = 0.73$, and the two groups did not differ in their arousal ratings for these same pictures, $p = 0.21$.

Table 3-12
IAPS: Group Means for Valence and Arousal

Rating	PD Group[a] *M (SD)*	Controls[a] *M (SD)*	*d*
Negative Valence	2.22 (0.70)	2.03 (0.69)	0.28
Positive Valence	7.20 (0.92)	7.08 (0.91)	- 0.13
Arousal	5.73 (0.62)	6.03 (0.69)	0.47

Note. Means reflect average score per item. *d* = standardised mean difference. The differences were not significant at the .01 level.
[a] $n = 16$ for each group.

3.6 Social Cognition

It was anticipated that the PD group would show deficits on social cognition tasks compared to the control group. A total score was computed and served as the dependent measure for each task. As predicted, on TOM items, the PD group was less able than controls to explain that a character in the cartoon had a mistaken thought or belief, $F(1, 31) = 9.42$, $p = 0.005$. Refer to Figure 3-4 and Table 3-13 on the following page. Less expected was the fact that, on the non-TOM items too, the PD group was not as able as controls to give a full and explicit explanation highlighting violations of social norms, $F(1, 30) = 7.80$, $p = 0.009$.

Figure 3-4
TOM: Mean Scores for Social Cognition

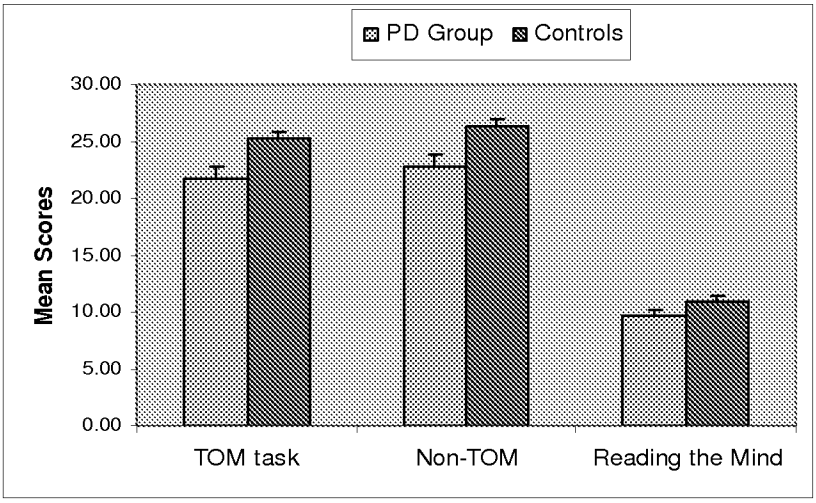


Table 3-13
TOM: Group Means for Social Cognition

Task	PD Group[a] *M (SD)*	Controls[a] *M (SD)*	*d*
TOM	21.75 (4.06)	25.25 (2.08)	1.09*
Non-TOM	22.75 (4.45)	26.31 (2.50)	0.99*
Reading the Mind	9.75 (1.81)	10.88 (2.22)	0.56

Note. d = standardised mean difference.
[a] $n = 16$ for each group.
*$p < .01$.

On the "Reading the Mind in the Eyes" task, the PD group was able to label the emotion expressed through a pair of eyes as well as the control group, $F(1, 30) = 2.48$, $p = 0.13$. Refer to Figure 3-4 and Table 3-13 above.

3.7 Cued autobiographical memory

It was anticipated that the PD group would use more words and speak for longer than controls when recollecting autobiographical events associated with emotion words. The mean word count per individual for the non-emotion words was used as a

covariate in an ANCOVA analysis. This procedure was performed to control for idiosyncratic differences in verbosity among all participants. There was a significant effect for the covariate, $F(1, 28) = 97.92$, $p < 0.01$, indicating that as the participants' verbosity increased for non-emotion words, it also increased for emotion words. Refer to Table 3-14 below for adjusted and non-adjusted means. When emotion words were used as cues to elicit memories, there were no significant overall differences between the two groups in number of words spoken, $F(1, 28) = 0.40$, $p = 0.54$. Pairwise comparisons revealed that the number of words spoken by the two groups did not differ for any emotion, $p > 0.23$.

Table 3-14
Group Means in Total Number of Words Spoken

Emotion	PD Group[a] Adjusted *M (SD)*	PD Group[a] Nonadjusted *M (SD)*	Controls[b] Adjusted *M (SD)*	Controls[b] Nonadjusted *M (SD)*	*d*[c]
Happy	52.15 (27.58)	55.73 (43.58)	53.17 (27.56)	49.81 (29.49)	- 0.04
Anger	83.21 (50.39)	90.60 (92.89)	85.49 (50.36)	78.56 (43.52)	- 0.05
Fear	77.89 (36.06)	82.46 (46.74)	76.98 (36.08)	72.68 (48.81)	0.03
Disgust	62.02 (36.75)	67.93 (59.28)	78.42 (36.72)	72.87 (50.81)	- 0.46

Note. *d* = standardised mean difference. The differences were not significant at the .01 level.
[a] $n = 15$. [b] $n = 16$. [c] *d* is based on adjusted means.

A similar analysis was conducted for discussion length, using the mean length of discussion (in seconds) for the non-emotion words as the covariate. There was a significant effect for the covariate, $F(1, 28) = 53.37$, $p < 0.01$: as the participants' discussion length increased for non-emotion words, it also increased for emotion words. Refer to Table 3-15 on the following page for adjusted and non-adjusted

means. When emotion words were used as cues to elicit memories, there were no significant overall differences between the two groups in length of discussion, $F(1, 28) = 0.01$, $p = 0.98$. Pairwise comparisons revealed that the discussion length did not differ between groups for any emotion, all $p > 0.22$.

Table 3-15
Group Means in Discussion Length

Emotion	PD Group[a] Adjusted *M (SD)*	PD Group[a] Nonadjusted *M (SD)*	Controls[b] Adjusted *M (SD)*	Controls[b] Nonadjusted *M (SD)*	*d*[c]
Happy	30.49 (13.94)	31.47 (20.04)	25.48 (13.92)	24.56 (15.77)	0.37
Anger	41.83 (22.04)	43.27 (34.29)	41.73 (22.04)	40.38 (19.29)	0.00
Fear	41.97 (17.47)	43.40 (23.76)	38.03 (17.48)	36.69 (24.48)	0.23
Disgust	33.08 (20.88)	34.20 (23.34)	42.61 (20.84)	41.56 (25.36)	- 0.47

Note. *d* = standardised mean difference. The differences were not significant at the .01 level.
[a] $n = 15$. [b] $n = 16$. [c] *d* is based on adjusted means.

3.8 Correlational analyses

A Pearson product-moment correlation analysis was performed for the PD group on the experimental tasks, i.e. emotion discrimination/recognition, social cognition, and cued autobiographical memory, with the DASS and disease variables. There were no significant correlations between any of the experimental tasks and levels of anxiety or stress, all $p > 0.03$, indicating that anxiety and stress did not significantly influence emotion processing performance. There was a positive correlation between levels of depression and FAB-r emotion prosody recognition that just reached the significance level, $r = 0.61$, $p = 0.01$. Somewhat unexpectedly, this result suggested that as depression levels increased, performance on this task improved. Refer to Table 3-16 on the following page. There were no significant correlations between any of the

experimental variables and disease severity as measured by motor function, all $p > 0.50$, indicating that severity of motor function did not significantly influence emotion processing. There was a positive correlation between the IAPS high valence measure and disease duration (just significant at $r = 0.61$, $p = 0.01$), indicating that as the duration of the disease increased, the PD group rated pictures with high valence as more pleasant.

Table 3-16
Pearson Correlations Between Disease Variables and Mood and Experimental Tasks

Experimental Tasks	Disease Duration	Disease Severity	Depression	Anxiety	Stress
Ekman	0.37	0.15	-0.10	-0.32	-0.35
MSFDE	-0.12	0.04	0.16	-0.15	-0.07
FAB Discrimination	-0.02	-0.13	0.12	0.16	-0.09
FAB Recognition	-0.30	0.05	0.61*	0.31	0.55
FAB Conflicting	-0.03	-0.03	0.44	0.26	0.25
Vignettes	0.24	0.10	0.34	-0.34	-0.06
Imagery	-0.24	-0.02	0.24	0.14	0.00
Mind in the Eyes	-0.13	-0.18	0.34	-0.20	0.00
TOM	-0.28	-0.16	-0.07	0.08	0.06
Non-TOM	-0.47	0.09	-0.01	-0.01	0.05
IAPS Positive Valence	0.61*	0.06	-0.23	-0.33	-0.17
IAPS Negative Valence	-0.21	0.14	-0.15	0.08	0.10
IAPS Arousal	-0.05	0.08	-0.05	-0.26	-0.02
Crovitz Memory DL[b]	-0.23	-0.17	-0.24	0.05	-0.36
Crovitz Memory TW[c]	-0.28	-0.13	-0.08	-0.08	-0.14

[a] $n = 16$ for all variables. [b] Mean discussion length for the Crovitz task. [c] Mean total number of words for the Crovitz task.
*$p = .01$.

CHAPTER 4: DISCUSSION

There is considerable controversy in the literature as to whether PD causes deficits in emotion processing and if so, to what extent. The present study was the first paper to address this question by using a broad range of tests, covering basic and complex emotion processing, over multiple modalities. Although the sample sizes were small, which limited power to some degree, using a conservative decision criterion, there were significant findings that further knowledge about emotion processing in PD.

4.1 Intact emotion processing

As expected, PD did not have an impact on emotion comprehension when tasks either involved lower level processing or contained semantic information that could be used as a compensatory mechanism in processing emotions.

4.11 Lower level processing

As predicted, the performance of the PD group in recognising facial expressions from prototypical photographs was unimpaired for each of the emotions. Both groups had similar accuracy rates for happiness, fear, anger and disgust. These findings were in agreement with other studies (Adolphs et al., 1998; Dujardin et al., 2004; Pell & Leonard, 2003; Suzuki et al., 2006) in showing that participants with PD were able to recognise prototypical expressions as well as controls. Similarly, the PD group was able to discriminate between emotions on a simple task of emotion prosody (see also Borod et al., 1990; Pell & Leonard, 2003). These findings both demonstrated intact emotion comprehension on tasks involving lower level processing.

4.12 Semantic knowledge of emotions

PD participants performed well on prosody recognition tasks where the semantic verbal content and prosodic message were congruent. This indicates that provided they have supporting semantic information, participants have no difficulty recognising emotional prosody across all emotions.

Similarly, the PD participants had no difficulty recognising emotions conveyed through written vignettes. The intact performance on this task added further support to the notion that PD does not affect the semantic representation of emotional concepts as such. It also suggested that any impact of basal ganglia damage on facial expression recognition, and in particular recognition of disgust, does not extend to the conceptual knowledge of these emotions. This finding has received support in previous research (Blonder et al., 1989; Calder et al., 2000).

As anticipated, following Bowers et al. (2006), the PD group did not demonstrate reduced sensitivity in their valence ratings while looking at emotionally-laden images. Although participants were asked to rate the amount of happiness they *felt* while viewing emotional images, it was expected that they would also use their conceptual knowledge of the meaning of happiness to complete the task. For example, if viewing a pleasant scene, their rating of "happiness" would include not only their feelings about this word but also their knowledge of its meaning. Similarly to the PD group's performance in recognising congruent emotion prosody and written vignettes, this task provided further evidence of preserved conceptual knowledge about emotions in participants with PD.

4.13 Arousal and negative affect

When rating arousal in response to emotional images, contrary to expectations, the PD group did not show reduced sensitivity in their arousal levels. Although Bowers et al. (2006) reported that the PD group showed muted startle enhancement and reduced arousal ratings, they only used images of negative affect. Wieser et al. (2006) also demonstrated that participants with PD showed reduced arousal ratings for images of negative affect, and concomitantly that there were no differences between the PD and control groups when rating pictures of neutral or positive affect. In the current study, both positive and negative affective images were used, with only 15 stimuli in each group. The discrepancy in findings between studies may be due to the fact that PD has only subtle effects on arousal, particularly associated with negative affect, so that a greater number of negative stimuli may be necessary to bring these subtle differences to light.

4.2 Deficits in emotion comprehension

It was anticipated that PD participants would be impaired on tests of complex emotion processing. These effects would in turn impact performance in social cognition tasks, which also rely on complex emotion processing skills.

4.21 Complexity in emotion processing

As discussed in Pell (1996), it was anticipated that PD would disrupt the efficiency of emotion processing, resulting in deficits on complex prosody recognition tasks. The PD group were indeed impaired in recognising fearful tones but not other emotional tones. Deficits in fear have been supported by other research involving PD and

emotion prosody (Breitenstein et al., 1998; Dara et al., 2008). It should be noted, however, that disgust was not a response choice for any of the prosody measures.

In contrast to tests of simple facial expression recognition and congruent prosodic utterances, the PD group was also impaired at recognising angry and neutral (but not sad or happy) tones on a conflicting emotion prosody task, confirming the findings of (Breitenstein et al., 2001). The results implied that reduced efficiency in emotion prosody is evident on tasks with more complexity, in which semantic knowledge cannot be used as an aid in comprehension.

4.22 Complexity in social cognition

As predicted, the PD group did not perform as well as controls on a social cognition task that measured both non-TOM items, inferring violations of social norms, and TOM items, inferring false beliefs held by other people. The differences between the two groups on the non-TOM portion of the task may be attributable to deficits in complex reasoning or executive function. This result is not surprising since executive function deficits have been well established in PD research (Lewis et al., 2003; Mindham & Hughes, 2000; Monchi et al., 2004; Peavy et al., 2001).

The reduced performance of the PD group in TOM reasoning was also found by Saltzman (2000) and Mengelbeg and Siegert (2003). While Saltzman (2000) found that performance on *some* executive function tasks was related to *some* of their TOM measures, Mengelbeg and Siegert (2003) found that deficits in their TOM tasks were unrelated to executive function. Executive function was not directly tested in this study. Sabbagh (2004) argued that TOM requires additional skills other than those

responsible for executive function, specifically reasoning about and decoding of, the mental state of others, with each process requiring distinct neural circuits. Both he and Rolls (2004) argued that the ability to recognise facial and vocal expression, which relies on fronto-striatal networks, was necessary in order to decode the mental state of others. In the present study, the PD group's deficits in TOM were arguably related to their reduced efficiency in emotion processing. For example, their inefficiencies were highlighted on emotion prosody tasks that required more complexity, such as recognising emotions when the semantic and prosodic messages were incongruent. TOM tasks are similarly complex and rely on an intact emotion processing system.

In contrast to the TOM task, the PD group's performance did not differ from controls on the "Reading the Mind in the Eyes" task, which required them to decipher the mental state of others from images of their eyes only. This result was similar to that found on the less difficult facial expression task, and was not expected as this task is considered to be a measure of social cognition and is thought to require similar skills to the TOM task. "Reading the Mind in the Eyes" is a test of social cognition since the eyes are intended to convey complex mental states involving a belief or intention, whereas, facial expression recognition involves universally accepted basic emotions and does not require an attribution of a belief or intention (Baron-Cohen et al., 2001). However, unlike the cartoon task "Reading the Mind in the Eyes" only requires one stage of TOM processing, i.e. the decoding of another's mental state (Baron-Cohen et al., 2001); it does not involve reasoning about the mental state of others. In contrast, the cartoon task not only involves two stages, but it requires the processing of a combination of stimuli, such as the facial expressions of the characters, their body

movement, and the relationship between characters and objects in the cartoon. This increased complexity of the cartoon task may again explain why the PD group did not perform as well as controls whereas there were no differences seen on the other task.

4.3 Summary of deficits and their neural correlates

Taking into account the findings across tests of emotion comprehension, what generalisations can be made about the nature of emotion processing deficits in PD and their corresponding neural substrates?

4.31 Disgust and the basal ganglia

It was anticipated that in reducing the intensity of facial expressions, and thereby increasing the difficulty of the task, the PD group would show deficits in recognising emotions. When comparing facial expressions of low intensity, high intensity or combined intensities, there were no differences in performance between the two groups apart from a trend toward significance for disgust. More robust deficits in the recognition of disgust have been shown in other studies that have tested participants with PD or with other basal ganglia lesions (Calder et al., 2000; Dujardin et al., 2004; Sprengelmeyer et al., 2003; Suzuki et al., 2006), suggesting a role for the basal ganglia in the processing of disgust in particular.

Performance in relation to disgust was also noteworthy on a cued autobiographical memory test. Taking into account individual differences in verbosity, Crucian (2001) tested participants with PD on a similar task and found that verbal output was higher and discourse was longer compared to controls when high arousal (anger, fear) cues were used compared to low arousal (happy, sad) ones. In the present study, disgust

was used instead of sadness as one of four emotion cues since it has been found to be specifically impaired in PD more than other emotions (Dujardin et al., 2004; Suzuki et al., 2006). Although there were no differences between the two groups in amount or duration of verbal output, disgust was the only emotion in which the PD group's absolute output was less than the controls both before and after adjustments were made for verbosity. Again, this finding supported the idea of participants with PD having less fully formed mental representations for disgust.

4.32 Implications of task difficulty

A counter argument to the idea of specific neural substrates subserving particular emotions, such as the amygdala and fear, was put forward by Rapcsak et al. (2000). They argued that deficits in recognising fear from facial expressions are a result of task difficulty and do not reflect dedicated neural systems for fear involving the amygdala and cortical regions in the right hemisphere. They reviewed facial expression recognition in cross-cultural studies with normal populations and reported that negative emotions in general were more difficult to process, with fear being the most difficult of all the basic emotions to process. When testing patients with brain lesions, they found that there was no laterality of effect when processing fear; patients with left, right or bilateral brain damage were no different in fear recognition. Additionally, patients with amygdala damage were no worse than patients without amygdala damage. They found that the amygdala did not have a specific role for fear but may have a role for facial affect processing in general.

Suzuki et al. (2006) directly addressed the issue of task difficulty in their study. They tested participants with PD using a conventional facial expression recognition task

and one in which they controlled for difficulty. Although they found no deficits on the conventional task, the PD group performed significantly worse in recognising disgust on the task that controlled for difficulty. In contrast to Rapcsak's et al. (2000) argument, their findings supported a specific role for the basal ganglia and its connections in the processing of disgust.

In the current study, the PD group showed deficits in fear recognition along with angry and neutral prosody. This finding partly supported Rapcsak's (2000) argument in that both fear and anger were the most difficult items for the PD and control groups on their respective tasks (judging by the number wrong). However, the fact that the PD group also showed deficits in processing neutral tones, which were not the most difficult, does not support their argument. Additionally, the PD group had difficulty in recognising facial expressions of disgust (trend toward significance). These stimuli, again, were not the most difficult to decipher, and in fact, were easier to recognise than both fear and anger. Taken together, these findings suggest that although task difficulty may be a contributing factor in some of the results, there are specific deficits that cannot be explained by task difficulty and are a result of PD.

4.33 Negative emotions

Emotion processing deficits were primarily found in emotions with negative valence. The PD group's performance was worse when processing fear, anger, and neutral tones. Deficits in one or more negative emotions have been found extensively in previous research (Bowers et al., 2006; Breitenstein et al., 1998; Dara et al., 2008; Dujardin et al., 2004; Pell & Leonard, 2003; Suzuki et al., 2006).

The differences between the PD and control groups in emotion comprehension demonstrated, not an absolute loss, but a reduced efficiency in the output of the basal ganglia as shown in complex tasks. The findings suggested that this reduced output had an effect on the basal ganglia's connections to frontal areas, thereby influencing cognitive appraisals and behavioural actions, such as choosing an emotion label (Dara et al., 2008; Pell, 1996; Pell & Leonard, 2003). While Dara et al. (2008) argued that the basal ganglia may only be responsible for processing negative emotions, findings from Clark, Neargarder, and Cronin-Golomb (2008) supported a broader role for the basal ganglia to include emotions with positive valence. They found deficits in anger, fear, and surprise among PD participants. The results from this study, in which the PD group had deficits in processing neutral tones as well as negative ones, suggested a broader role for the basal ganglia as well.

4.34 Is emotion processing multimodal?

Deficits in emotion processing were not found across modalities nor were there deficits in particular emotions in more than one modality. Although the PD group's performance was worse on a social cognition measure, which is associated with complex emotion processing, prosody was the only mode in which the PD group showed deterioration in performance. Results from previous research, as to whether PD produces deficits in more than one mode of processing, have been conflicting. A few studies have tested PD participants on both facial expressions and prosody. Some have found deficits on both types of tasks (Blonder et al., 1989; Breitenstein et al., 1998) while others have found deficits only in emotion prosody (Borod et al., 1990) or only face processing (Kan et al., 2002). Calder (2000), in particular, demonstrated cross-modal deficits (facial expressions, emotion prosody, and the experience of

disgust) in disgust recognition for a patient with lesions to both the basal ganglia and insula.

In contrast to the current study, no previous research has tested PD participants over a broad range of emotion processing tasks. Although findings do not support a common neural substrate across modalities, semantic information may have been a confounding variable that distorted results across more measures than was anticipated. As discussed previously, their intact conceptual knowledge of emotions helped the PD group decipher emotion vignettes and some of the prosody tasks. This knowledge may have also helped them when rating the valence of emotionally-laden pictures. For these reasons and those relating to complexity, evidence for a multimodal role in emotion processing remains unclear.

4.35 Heterogeneity of effects

There were no differences between the groups when imagining the facial components of the six basic emotions. These findings were in contrast to those found by Jacobs et al. (1995) in which the PD group performed worse overall on an emotion imagery task, and in particular, in imagining the facial expression of sadness. They attributed the ability to imagine facial expressions to a neural substrate subserved by the basal ganglia and the right hemisphere. In the current study, it was surprising that the PD group did not show deficits in imagining emotions. These findings raised two possibilities. There may be some redundancy in emotion processing such that the PD group uses compensatory mechanisms for analysing emotion imagery notwithstanding basal ganglia damage. Alternatively, PD may have heterogeneous effects on the basal

ganglia, resulting in different patterns of emotion deficit in some PD patients compared to others.

In considering the findings from studies that have examined emotion processing in PD, questions remain regarding the extent and nature of deficits. Although a few studies have not found any deficits in recognising emotions in PD, most studies have reported some type of emotion deficit. However, conclusions regarding whether deficits involve one or more emotions remain unclear. The conflicting results with respect to emotion type and modality may be a result of the heterogeneous effects produced by the disease and the variability of its course. Although PD is diagnosed according to a set of clinical symptoms, such as bradykinesia, a resting tremour, rigidity, and asymmetric onset, the predominant symptoms among individuals vary. The course of the disease, along with long term responses to dopamine medication, is quite variable. Responses to medication often take one or more of the following patterns. Patients with PD may experience increasingly severe fluctuations in movement and dyskinesias, increasing cognitive impairment and psychosis, or increasing postural instability and falls with gait difficulties and speech problems (Marsden, 1994). It is not surprising, therefore, that due to the variability in the motor and cognitive signs of the disease, there is also heterogeneity in emotion processing effects. Although PD is known to affect dopaminergic neurons in the substantia nigra pars compacta, the specific areas of the basal ganglia that are affected are largely unknown and may differ between individuals. Whether PD affects one area or another of the basal ganglia may determine the type and modality of emotion deficits. Additionally, PD's impact on social cognition, as a result of the basal ganglia's

connections to frontal areas, may also be somewhat disparate as demonstrated in the current study.

4.36 Influence of disease factors and mood on emotion processing

The overall influence of disease factors, such as disease severity and duration, on emotion processing performance was circumscribed. As expected, disease severity had no significant associations with performance on emotion recognition tasks. Disease severity, as measured by the Hoehn and Yahr scale, only takes into account the motor effects of the disease, which have not been found to be associated with emotion processing deficits in previous research (Dara et al., 2008; Dujardin et al., 2004; Jacobs et al., 1995; Suzuki et al., 2006). Similarly to disease severity, disease duration did not have a significant relationship with most emotion processing measures. This was expected since the course of PD is quite variable, and the duration of the disease is not always a clear indicator of severity. However, there was a positive association with performance on rating pictures of positive affect. This finding may be an indication that as the duration of PD increases, the length of time with reduced mobility also increases. Therefore, pleasant images that involve activities requiring intact mobility may be placed in a more positive light the longer a person has lived with PD.

As expected, few significant associations were found between mood and emotion recognition performance. There were no relationships between levels of anxiety and stress and the emotion processing measures. Several studies have reported an absence of associations between mood disturbances and emotion processing deficits, suggesting a separate neural substrate subserving emotion processing (Bowers et al.,

2006; Dara et al., 2008; Dujardin et al., 2004; Pell & Leonard, 2003). However, there was a significant association between depression levels and emotion prosody recognition. This result may be due to the performance of two patients, in particular, who scored outside the range of the remaining PD group. Although they had normal levels of depression, they performed the most poorly on the emotion prosody task.

There were no consistent patterns overall between disease factors, mood and emotion processing. It should be noted, however, that due to small sample sizes a correlation needed to reach at least 0.623 to be significant. This statistic was quite high and meant that some correlations, considered to be a large effect size according to Cohen, were not significant.

4.4 Design shortcomings and future directions

In addition to reasons discussed previously, the lack of more pervasive deficits across emotions and modalities may also be attributed to aspects of the study's design.

4.41 Small sample size

Several studies reporting deficits in emotion processing with PD had comparable sample sizes (Blonder et al., 1989; Breitenstein et al., 2001; Dara et al., 2008; Dujardin et al., 2004; Mengelberg & Siegert, 2003; Pell, 1996; Saltzman et al., 2000; Wieser et al., 2006). However, due to the large number of tests administered and consequent analyses performed in the current study, a more stringent significance rate of 0.01 was used to reduce the likelihood of type I errors.

This combination of a small sample size and a stringent significance level meant that differences between groups, which were not significant, produced moderate - strong effect sizes in some instances. These included facial expression and prosody recognition, emotion imagery, and social cognition. The overall pattern of non-significant results which suggested moderate-strong effects sizes did not form a coherent pattern, suggesting that rather than a problem with power, they were potentially type I errors.

4.42 Test Selection

The broad range of tests aimed at measuring different aspects of emotion processing was novel and helpful in gathering more information about the range of emotion deficits in PD. However, the type of stimuli used and the way in which some of the measures were scored could be improved in future studies.

Low and high intensity expressions, which only featured one emotion at a time, were chosen for this study instead of choosing facial expressions portraying blended emotions (see Calder et al., 1996). It may have been more relevant to use blended emotions since they are encountered more often in everyday life and may, thus, have more ecological validity. Additionally, a forced choice labeling task was used as a response mechanism. More information would have been gained if the participants were asked to rate the emotion intensity of each facial expression with respect to all of the six emotions as has been done in previous work (Dujardin et al., 2004; Suzuki et al., 2006). This scoring method not only adds to the amount of information gathered but increases the complexity of the task and may have elucidated subtle deficits in facial expression recognition that were not found with the existing design.

On the autobiographical memory test, the dependent measures, total word count and length of discourse, created a quantitative scoring method for responses that were qualitative in nature. This method was helpful in creating a more objective measure of performance. However, the measures could be improved further given the large variability in output between and within groups on this task. One possible way to reduce variability would be to rate participants for their specificity of memory. Responses could be scored according to amount of detail using strict criteria for what constitutes relevant information, such as date of memory, place, who was involved etc. Another measure that would be useful is quantifying the amount of emotionality conveyed through their memories. Points could be given for describing specific feelings or particular emotions.

4.43 Executive function

Executive function deficits have been firmly established in the PD literature (Lewis et al., 2003; Monchi et al., 2004; Peavy et al., 2001) and were, therefore, not directly tested in this study. However, it would be useful to include these tests in future studies in order to analyse their association with emotion processing measures. For example, establishing that there is no significant relationship between executive function and emotion prosody or TOM would have provided further support for emotion processing as a distinct entity from executive function.

4.44 Functional imaging and physiological responses

In order to gain more information about the neural substrates underpinning emotion processing, functional imaging (fMRI), EEG recordings or physiological measures, such as the startle eyeblink response, should be recorded while participants are

undergoing testing. Few studies have recorded brain activity or physiological responses while PD participants perform emotion processing tasks. Wieser et al. (2006) measured PD participants while viewing emotionally-laden pictures by means of event-related potentials (ERPs), and Bowers et al. (2006) measured the startle eye blink responses of PD participants while watching aversive pictures. However, both of these studies only tested the participants while viewing emotional pictures. Future research should concentrate on using these measures over a range of tests, such as the test battery that was used in the current study. A study design such as this would shed light on the neural correlates of cross-modal emotion processing in PD.

4.45 Response patterns

Although it is beyond the scope of this study, it would be interesting for future research to analyse the response patterns between and within groups. Determining the types of confusions that are made and whether participants with PD choose some emotions less often than others may provide valuable qualitative information. For instance, it may indicate whether some emotion representations are less fully formulated in the mind as a result of PD.

4.5 Conclusions

Based on the findings from the present study, emotion processing deficits in PD can best be characterised as inefficient processing, rather than an absolute loss in ability. These inefficiencies are elucidated through tasks that require complex emotion comprehension, such as social cognition or incongruent prosody, in which participants are not able to use their semantic knowledge as an aid. Deficits in the conceptual knowledge of emotions were not demonstrated. Although there was no evidence to

suggest that deficits from PD include more than one mode of emotion processing, i.e. only prosody was affected, semantic information may have been a confounding factor in aiding performance across several tests. Whether the basal ganglia have a multimodal role in emotion processing remains unclear and requires further study. There was limited support for the basal ganglia's role in the processing of distinct emotions, such as disgust. However, the heterogeneous effects of PD with regard to motor symptoms and cognition suggest that it may also have heterogeneous effects on emotion processing. Assuming that PD has disparate effects within the basal ganglia and its connections to the frontal areas, this variability could explain the lack of consensus in the literature as to the type and extent of deficits in emotion processing in PD.

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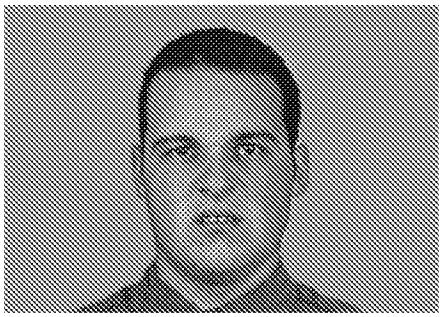
APPENDICES

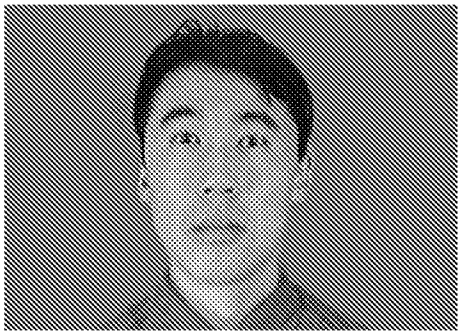
Appendix 1: Examples of Low and High Intensity Facial Expressions from the Montreal Set of Facial Displays of Emotion

White female – 40% intensity happy

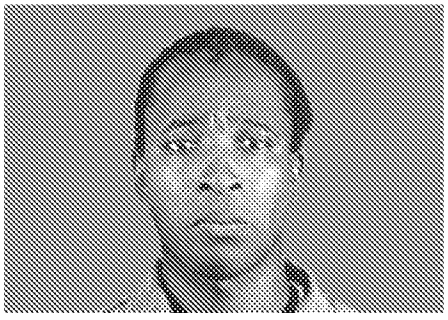


White Male – 80% intensity disgust

Asian female – 80% intensity anger



Asian male – 40% intensity fear



African male – 80% intensity Sadness

African female – 40% intensity disgust

Beaupré, M., G., & Hess, U. (2005). Cross-cultural emotion recognition among Canadian ethnic groups. *Journal of Cross-Cultural Psychology, 36*(3), 355-370

Appendix 2: Emotion Vignettes Questionnaire

Please read each short story silently then circle the word that best describes the emotion felt by the main character.

1. Thomas went to his hairdresser, George, to get his hair washed and trimmed. When he finished cutting his hair, George charged him $25 more than the usual price. When Thomas asked why, George said he wanted to buy a new sports car. Thomas felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

2. Bryan's friend, Tony, had moved to the country several years ago. They kept in touch by phone and had remained close. The other day Tony called him to say that he may be moving back to the city because of a job offer. Bryan felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

3. Today was the school swimming carnival. Nick was 8 years old and it was the first time he had entered in the swimming races. He would have to swim a full length of the pool which he had never done before. Nick felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

4. Susan was reading on a bus when the man next to her started making gagging sounds. After several minutes, he vomited on the seat next to her. Susan felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

5. Timothy had owned a dog for several years. The dog recently developed a rare disease, which the veterinarian said would be fatal. Timothy felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

6. Sheryl had a good friend Belinda whom she had known from childhood. Belinda organised a birthday party for Sheryl, but she invited her own friends instead of Sheryl's. Sheryl felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

7. Kate had not studied very well for her undergraduate biology exam. Instead, she had spent her time working and partying with her friends. When the marks were posted, she had actually received a passing grade. Kate felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

8. Meredith had a favourite doll that she had kept for several years from the age of 6 months. Recently, the doll was starting to come apart at the seams on the neck and was unrepairable. Meredith realised that she wouldn't have the doll for much longer. Meredith felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

Appendix 2: Emotion Vignettes Questionnaire

9. Luke had spent the last 2 years building his dream home while working full time at another job. He was having a house warming party to celebrate the completion of his project. Luke felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

10. Sid was working for a big bank. He was hoping for a bonus for his exceptional performance this year. However, his boss announced to the employees that the company would not be giving out any bonuses this year because management would be receiving large salary increases. Sid felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

11. Ally and Chris had been married for 35 years, had raised four children, and had a loving marriage. After suffering from cancer for two years and being told by the doctors that there was nothing more they could do, Chris died in his home at the age of 55 with Ally by his side. Ally felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

12. Sarah, her husband, and four children were travelling to her mother's house for a barbeque. Her sister and children, who were all similar ages to Sarah's children, were coming as well. Both families got along very well. Sarah felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

13. David worked at a video store for many years, and he finally saved enough money to buy his own store. On the day of his store's grand opening, an electrical fire started in his building. By the end of the day, it had destroyed all of his merchandise. David felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

14. After playing in the park with some of the neighbourhood dogs, Sam walked back to his house and noticed a funny smell. When he looked at the bottom of his shoe, he noticed that he had dog faeces smeared across the bottom of his shoe. Sam felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

15. Hannah thought that the most she could jog that morning would be 3 kilometres because she had been up late the night before. After running for 20 minutes and completing 3k, she found that she wasn't tired at all. Hannah felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

16. Bartholomew had been a good boy while shopping with his mother. She promised to buy him an ice cream if he behaved. At the end of the shopping trip, his mother told him that they didn't have time to buy an ice cream because she needed to buy a coffee. Bartholomew felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

Appendix 2: Emotion Vignettes Questionnaire

17. Emily had one best friend, Sally, since she was in preschool. After high school graduation, Sally moved with her family to America where she planned on attending university the following year. Emily stayed behind in Australia. Emily felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

18. Madeline was walking home from the theatre late at night when she heard heavy footsteps right behind her. Madeline felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

19. Tommy's 6th birthday was coming, and he and his mother were planning a party at the bowling alley. Bowling was one of Tommy's favourite activities. Tommy felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

20. When Ben was raking leaves in his back garden, a pigeon dropping fell on his forehead and ran down his face. Ben felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

21. James and his friends thought it would be funny to play a trick on his dog. They placed a banana peel on the floor. His dog slipped on it and broke its leg. James felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

22. Henry was five years old and starting his first day of school. He hadn't attended preschool, so he had never spent time away from his mother before. This would be the first time. Henry felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

23. Kayla loved her garden and took great pride in its beauty. While she was travelling, a terrible storm caused havoc in her town. When she arrived back home, she found that most of her flowers had been destroyed by the storm. Kayla felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

24. Kerry took her car to be repaired because the door lock was broken. When she picked up the car a few days later, the mechanic's bill was much larger than the estimate he had given her previously. She questioned the bill, but he would not discuss it. Kerry felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

Appendix 2: Emotion Vignettes Questionnaire

25. Samantha opened the medicine bottle without looking at the label. She took two tablets and swallowed them with a glass of water. She then glanced at the bottle and noticed that she had taken poisonous medication by accident. Samantha felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

26. Georgia cooked a lovely fish dinner. The next morning she opened up the rubbish bin to throw away a piece of paper, and the smell of the day old fish suddenly filled her nostrils. Georgia felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

27. Deborah was fast asleep at 3 am when she was awoken by the sound of a window being opened on the ground floor of her apartment and a man's voice whispering in her kitchen. Deborah felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

28. Frederick and his best friend were going to the cinema to see the latest Harry Potter movie. They were both huge fans of the whole series. Frederick felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

29. Betty was 78 years old, had recently been involved in a car accident, and was recuperating in hospital. The doctor told her that she needed to have her hip replaced, but she didn't like the thought of having surgery at her age. Betty felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

30. The professor asked the students how they would feel if they were asked to spit into an empty glass and then told to drink the liquid. The students felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

31. When Jackie came home from school, her pet bird, which was only 3 weeks old, was lying on the floor of the bird cage. She told her mother who took it out of the cage and examined it. She told Jackie that the bird must have died earlier that day. Jackie felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

32. When the Ferris wheel at the amusement park stopped at the top of the circle, Susan looked down at the ground through the bars. She didn't like the feeling of being up so high off the ground. Susan felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

Appendix 2: Emotion Vignettes Questionnaire

33. Carol bought a cup of coffee at her local café every morning. The staff knew her by name and always had her cappuccino ready when she arrived. On this particular morning, a new person was making coffee. As she reached to pick up her coffee, the new person spilled hot coffee all over Carol's new dress. Carol felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

34. Gretchen was expecting to find a piece of thread in her sewing kit. When she placed her hand in the kit, she found a stuffed toy instead. Gretchen felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

35. Albert was studying to be a medical doctor, but he found his anatomy and dissection classes very difficult. In particular, he didn't like peeling back the layers of fat from the inside of the abdominal cavity. Albert felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

36. Ben swam his fastest time in the school swim carnival after he had been training for several months. Ben felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

37. Matthew was playing cricket on Saturday with his friends. It was his turn to bat when Daniel tried to take the cricket bat away from him. Matthew told Daniel that he had just started batting, but Daniel didn't listen. Mathew felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

38. Bill was a rugby coach, and Alexander was the best player on the team. At the end of the season, Bill was adding up the point tallies for each player. Alexander was the only member of the team who had not scored any points against the opposing side. Bill felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

39. Neil and Deb decided to travel to Europe for their 10^{th} year wedding anniversary. Deb finished making arrangements for their flights and accommodation as planned. She was looking forward to their departure in a couple of weeks. Deb felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

40. Timmy was grocery shopping with his mother and running down the aisles when he noticed that he had lost sight of her. He turned around and couldn't find her anywhere. He could only see adults with strange faces walking up and down the aisle. Timmy felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

Appendix 2: Emotion Vignettes Questionnaire

41. During the spelling dictation in class, Deborah noticed that her teacher had spittle at the creases of his mouth. Deborah felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

42. It was a nice sunny day, and Katie and her daughter were walking the dog. They tried to do this activity together every day because they both enjoyed walking and talking about the day's events. Katie felt …

Happy ***Angry*** ***Sad*** ***Surprised*** ***Disgusted*** ***Fearful***

Appendix 3: Imagery of Emotion Questionnaire

Name: _____ Date: _____
SID: _____

Instructions: Please read each statement and *imagine* the emotion that is requested. Do not make the facial expression yourself, but *imagine* the emotion expression on the face of someone else. While doing this, answer the eight questions that follow. There are six emotion statements and 48 yes/no questions in all: 8 for each of the six emotions – happy, surprised, fearful, disgusted, sad, and angry.

Imagine that you are looking at the face of someone who is very happy.

Please answer yes/no to the following questions.

1.	Are the eyebrows frowning?	Yes	No
2.	Are the corners of the lips raised?	Yes	No
3.	Is the mouth open?	Yes	No
4.	Are the corners of the lips lowered?	Yes	No
5.	Are the corners of the eyes wrinkled?	Yes	No

Imagine that you are looking at the face of someone who is very surprised.

Please answer yes/no to the following questions.

1.	Are the eyebrows frowning?	Yes	No
2.	Are the corners of the lips raised?	Yes	No
3.	Is the mouth open?	Yes	No
4.	Are the eyes opened wide?	Yes	No
5.	Are the corners of the lips lowered?	Yes	No
6.	Are the eyebrows raised?	Yes	No
7.	Are the corners of the eyes wrinkled?	Yes	No

Imagine that you are looking at the face of someone who is very fearful.

Please answer yes/no to the following questions.

1.	Are the eyebrows frowning?	Yes	No
2.	Are the corners of the lips raised?	Yes	No
3.	Is the upper lip raised?	Yes	No
4.	Are the eyes opened wide?	Yes	No
5.	Are the corners of the eyes wrinkled?	Yes	No

Adapted from Bowers, L., Blonder, X, Feinberg T. & Heilman, KM (1991). Differential impact of right and left hemisphere lesions on facial emotion and object imagery. *Brain, 114*, 2593-2609.

Appendix 3: Imagery of Emotion Questionnaire

Imagine that you are looking at the face of someone who is very disgusted.

Please answer yes/no to the following questions.

1.	Are the eyebrows frowning?	Yes	No
2.	Are the corners of the lips raised?	Yes	No
3.	Is the mouth open?	Yes	No
4.	Are the eyes opened wide?	Yes	No
5.	Are the eyebrows raised?	Yes	No

Imagine that you are looking at the face of someone who is very sad.

Please answer yes/no to the following questions.

1.	Are the eyebrows frowning?	Yes	No
2.	Are the corners of the lips raised?	Yes	No
3.	Is the mouth open?	Yes	No
4.	Is the upper lip raised?	Yes	No
5.	Are the eyes opened wide?	Yes	No
6.	Are the corners of the lips lowered?	Yes	No

Imagine that you are looking at the face of someone who is very angry.

Please answer yes/no to the following questions.

1.	Are the eyebrows frowning?	Yes	No
2.	Are the corners of the lips raised?	Yes	No
3.	Is the mouth open?	Yes	No
4.	Is the upper lip raised?	Yes	No
5.	Are the eyes opened wide?	Yes	No
6.	Are the eyebrows raised?	Yes	No
7.	Are the corners of the eyes wrinkled?	Yes	No

Adapted from Bowers, L., Blonder, X, Feinberg T. & Heilman, KM (1991). Differential impact of right and left hemisphere lesions on facial emotion and object imagery. *Brain, 114*, 2593-2609.

Appendix 4: Theory of Mind Scoring Procedure

There are two types of cartoons:

1. Theory of Mind (TOM) Cartoon is where the humour depends upon what a character mistakenly thinks or does not know.

2. Non-Theory of Mind (Non-TOM) Cartoon is where the humour does not involve a character's false belief or ignorance but instead involves a physical anomaly or violation of a social norm.

TOM Scoring Instructions

3 pts: full and explicit explanation; response must include the fact that the character(s) has a mistaken thought or feeling or does not know something

2 pts: partial and/or implicit explanation

1 pt: reference to relevant parts of cartoon without further explanation

0 pts: irrelevant, incorrect or "don't know" answers

Non-TOM Scoring Instructions

3 pts: full and explicit explanation

2 pts: partial and/or implicit explanation

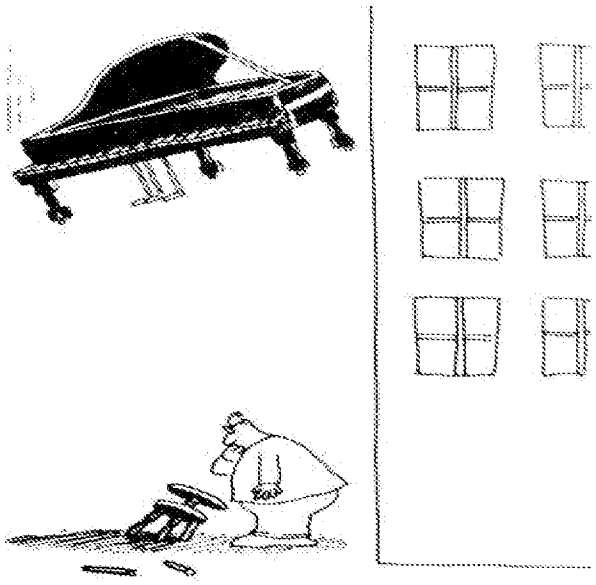
1 pt: reference to relevant parts of cartoon without further explanation

0 pts: irrelevant, incorrect or "don't know" answers

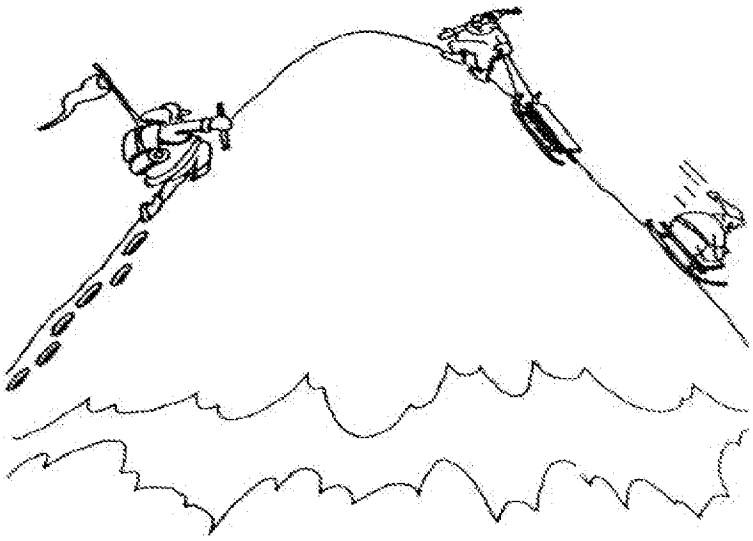
Scoring Based on:

Happé, F., Brownell, H. & Winner, E. (1999). Acquired 'Theory of Mind' impairments following stroke. *Cognition, 70*, 211-240.

Appendix 5: Examples of TOM and Non-TOM Cartoons



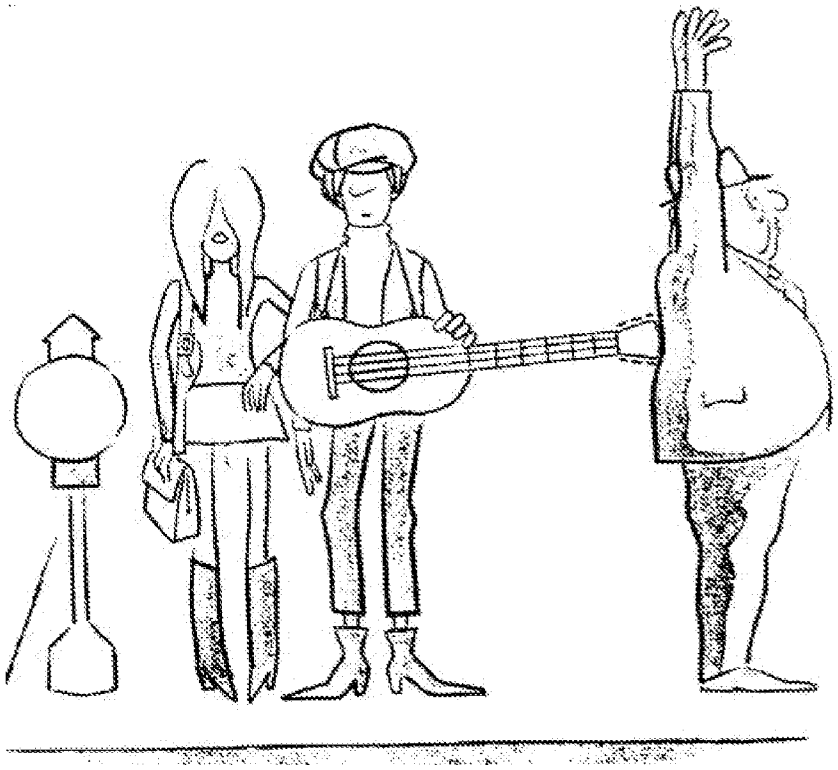
TOM Cartoon



TOM Cartoon

Gallagher, H. L., Happe, F., Brunswick, N., Fletcher, P. C., Frith, U., & Frith, C. D. (2000). Reading the mind in cartoons and stories: an fMRI study of 'theory of mind' in verbal and nonverbal tasks. *Neuropsychologia, 38*, 11-21.

Appendix 5: Examples of TOM and Non-TOM Cartoons



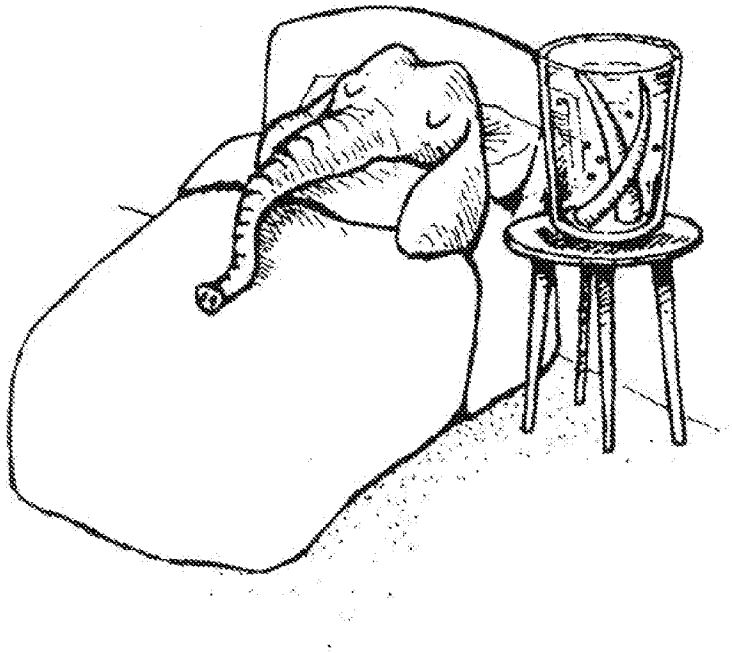
TOM Cartoon

TOM Cartoon

Gallagher, H. L., Happe, F., Brunswick, N., Fletcher, P. C., Frith, U., & Frith, C. D. (2000). Reading the mind in cartoons and stories: an fMRI study of 'theory of mind' in verbal and nonverbal tasks. *Neuropsychologia, 38*, 11-21.

Appendix 5: Examples of TOM and Non-TOM Cartoons

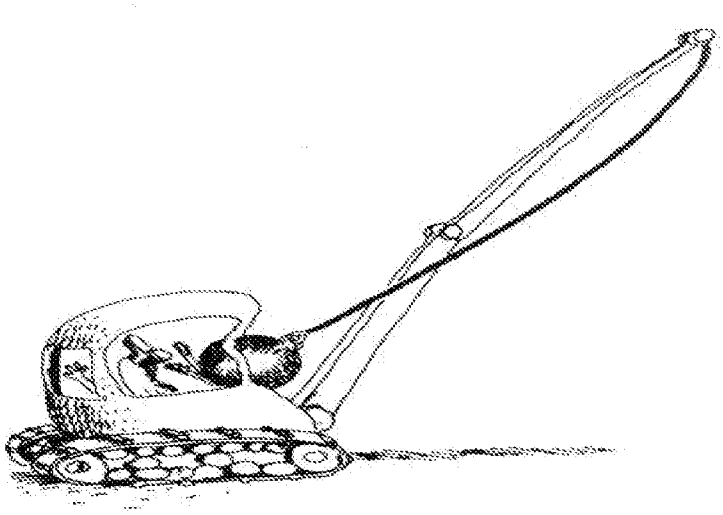
Non-TOM Cartoon



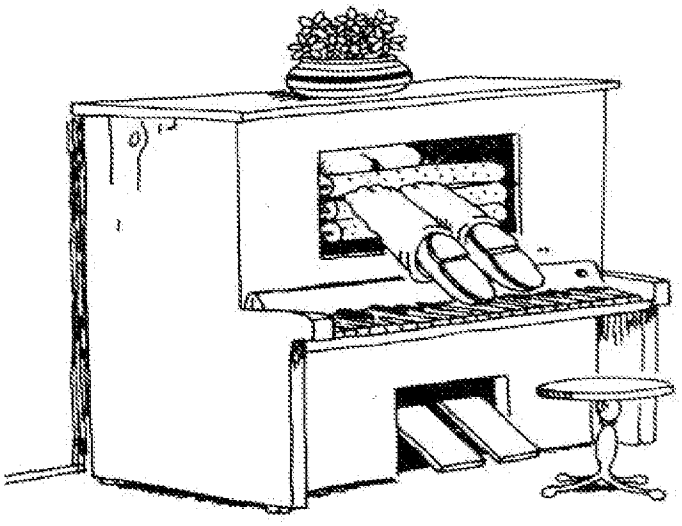
Non-TOM Cartoon

Gallagher, H. L., Happe, F., Brunswick, N., Fletcher, P. C., Frith, U., & Frith, C. D. (2000). Reading the mind in cartoons and stories: an fMRI study of 'theory of mind' in verbal and nonverbal tasks. *Neuropsychologia, 38*, 11-21.

Appendix 5: Examples of TOM and Non-TOM Cartoons



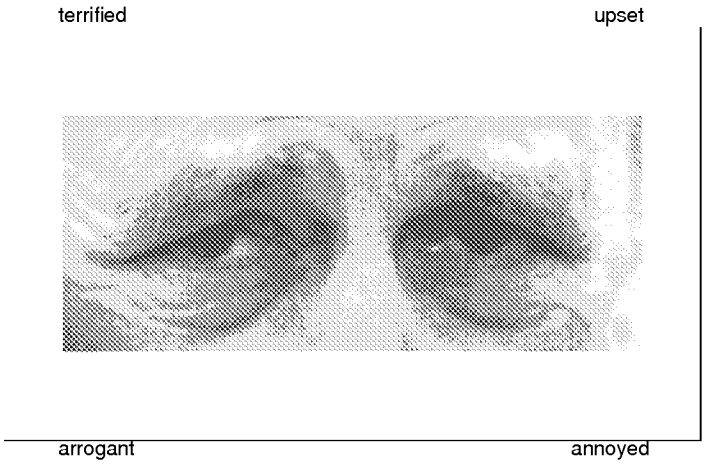
Non-TOM Cartoon



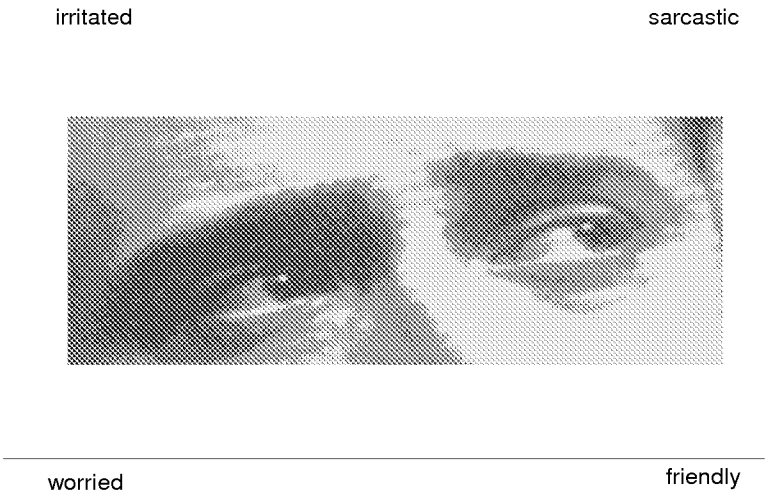
Non-TOM Cartoon

Gallagher, H. L., Happe, F., Brunswick, N., Fletcher, P. C., Frith, U., & Frith, C. D. (2000). Reading the mind in cartoons and stories: an fMRI study of 'theory of mind' in verbal and nonverbal tasks. *Neuropsychologia, 38*, 11-21.

Appendix 6: Examples of Stimuli from the "Reading the Mind in the Eyes" test



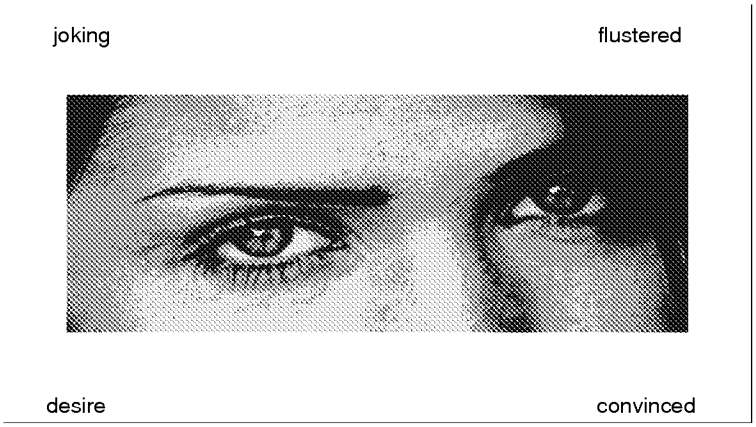
The correct answer is upset.



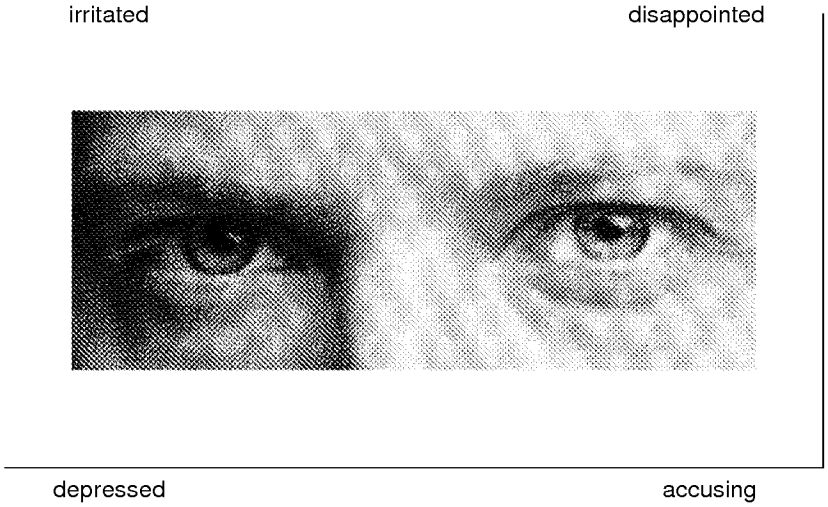
The correct answer is worried.

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The "Reading the Mind in the Eyes" test revised version: a study with normal adults, and adults with Asperger syndrome or High-functioning Autism. *Journal of Child Psychology and Psychiatry, 42*(2), 241-251.

Appendix 6: Examples of Stimuli from the "Reading the Mind in the Eyes" test



The correct answer is desire.



The correct answer is accusing.

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The "Reading the Mind in the Eyes" test revised version: a study with normal adults, and adults with Asperger syndrome or High-functioning Autism. *Journal of Child Psychology and Psychiatry, 42*(2), 241-251.

Appendix 6: Examples of Stimuli from the "Reading the Mind in the Eyes" test

The correct answer is hostile.

The correct answer is nervous.

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The "Reading the Mind in the Eyes" test revised version: a study with normal adults, and adults with Asperger syndrome or High-functioning Autism. *Journal of Child Psychology and Psychiatry, 42*(2), 241-251.

SYDNEY WEST
Area Health Service

PARTICIPANT INFORMATION

Title of Project: Emotional Processing in Patients with Parkinson's Disease

Names of Investigators: The study is being conducted by Dr. Margaret Charles and Ms. Molly Schafer,
Psychology Clinic, University of Sydney.

What is the purpose of the study?: To investigate further the nature of emotion processing in people with Parkinson's disease (PD) by using a range of tests. They include labeling facial displays of emotion, recognizing emotion conveyed through auditory and written means, an emotional imagery task, labeling affective pictures, and recalling past events.

Who will be invited to enter the study?: You have been invited to enter the study because you are suffering from Parkinson's disease. In addition, we will also need people of a similar age and educational background who do not have Parkinson's disease as a comparison group.

What will happen on the study?: You will be asked to complete a 2-3 hour session of testing at the Westmead Movement Disorders Clinic at Westmead Hospital. If you prefer, the research can be conducted at your home, with a family member or friend present. Testing will be divided with breaks or conducted over two sessions if needed. In this time, you will be asked to complete tasks assessing various aspects of your thinking, memory and emotion processing skills. With your permission, some parts of the testing may be video or audio taped to ensure that we capture your full responses.

Are there any risks?: Some patients may experience mild distress due to difficulty completing some of the tasks. Clinicians experienced in dealing with this problem will do the testing. You will be offered a break during testing or the opportunity to reschedule the session. Counselling will be provided should you require it.

Confidentiality: All aspects of this study, including results, will be strictly confidential and only the researchers will have access to any personal information and data gained from the study. Once scoring is complete, data will be deidentified and stored in a secure place for 7 years, then destroyed. Any publication of the results from this study will only use deidentified information.

Do you have a choice?: Your participation in this study is entirely voluntary. If you choose not to join the study, or you wish to withdraw from it at any time, your medical care will not be affected.

What are the benefits of taking part?: While we intend that this research furthers medical knowledge and may improve understanding and treatment of Parkinson's disease in the future, it may not be of direct benefit to you.

SYDNEY WEST
Area Health Service

PARTICIPANT INFORMATION

Title of Project: Emotional Processing in Patients with Parkinson's Disease

Complaints: If you have any concerns about the conduct of the study, or your rights as a study participant, you may contact the Westmead Hospital Patient Representative, Ms Jillian Gwynne Lewis, Telephone No: 9845 7014 or email: jillian_lewis@wsahs.nsw.gov.au

Contact details: When you have read this information, Molly Schafer will discuss it with you further and answer any questions you may have. If you would like to know more at any stage, please feel free to contact:
Molly Schafer, Intern Clinical Neuropsychologist: 0408 196 605 or,
Dr. Margaret Charles, Senior Lecturer: (02) 9351-3354.

If you have any problems while on this study, please contact **Dr. Margaret Charles.**

This information sheet is for you to keep.

SYDNEY WEST
Area Health Service

CONSENT TO PARTICIPATE IN RESEARCH

Title of Research Project: Emotional Processing in Patients with Parkinson's Disease

Name of Researcher: Molly Schafer, Intern Clinical Neuropsychologist at University of Sydney under the supervision of Dr. Margaret Charles, Senior Lecturer at University of Sydney

1. I understand that the researcher will conduct this study in a manner conforming to ethical and scientific principles set out by the National Health and Medical Research Council of Australia and the Good Clinical Research Practice Guidelines of the Therapeutic Goods Administration.

2. I acknowledge that I have read, or have had read to me the Participant Information Sheet relating to this study. I acknowledge that I understand the Participant Information Sheet. I acknowledge that the general purposes, methods, demands and possible risks and inconveniences which may occur to me during the study have been explained to me by Molly Schafer, and I acknowledge that I understand the general purposes, methods, demands and possible risks and inconveniences which may occur during the study.

3. I acknowledge that I have been given time to consider the information and to seek other advice.

4. I acknowledge that refusal to take part in this study will not affect the usual treatment of my condition.

5. I acknowledge that I am volunteering to take part in this study and I may withdraw at any time.

6. I acknowledge that this research has been approved by the Sydney West Area Health Service Human Research Ethics Committee.

7. I acknowledge that I have received a copy of this form and the Participant Information Sheet, which I have signed.

Before signing, please read 'IMPORTANT NOTE' following (please turn over)

Name of participant _____Date of Birth _____

Address of participant _____

Signature of participant _____Date: _____

Name of parent or person responsible (where applicable) _____

Address of parent or person responsible (where applicable) _____

Signature of parent or person responsible (where applicable) _____
Date:_____

Signature of researcher _____Date: _____

SYDNEY WEST
Area Health Service

IMPORTANT NOTE
This consent should only be signed as follows:

1. *Where a participant is over the age of 16 years, then by the participant personally.*
2. *Where the participant is between the age of 14 and 16 years, it should be signed by the participant and by a parent or guardian.*
3. *Where the participant is under the age of 14 years, then the parent or guardian only should sign the consent form.*
4. *Where a participant is under a legal or intellectual disability, eg unconscious, then particular consent should be sought from the Human Research Ethics Committee as to whether the person should take part in the research.*

INDEPENDENT WITNESS:

I, _____ (name of independent witness)

of _____ hereby certify as follows:

1. I was present when _____ ("the participant") appeared to read or had read to him / her a document entitled Participant Information Sheet; or I was told by _____ ("the participant") that he/she had read a document entitled Participant Information Sheet (*Delete as applicable)

2. I was present when _____ ("the researcher") explained the general purposes, methods, demands and the possible risks and inconveniences of participating in the study to the participant. I asked the participant whether he/she had understood the Participant Information Sheet and understood what he/she had been told and he/she told me that he/she did understand.

3. I observed the participant sign the consent to participate in research and he/she appeared to me to be signing the document freely and without duress.

4. The participant showed me a form of identification which satisfied me as to his/her identity.

5. I am not involved in any way as a researcher in this project.

Name of independent witness
_____

Address
_____

Signature of independent witness _____ Date:_____

Relationship to participant of independent witness _____