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The Measurement and Nature of Impulsivity in Parkinson's disease

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), approval number HR85/2016.

Signature:

Date: 13/05/2020

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Abstract

Parkinson's disease (PD) is associated with numerous motor and non-motor symptoms that can significantly affect the lives of people with the disorder and their family/friends (Elmer & Hauser, 2011; Kalia & Lang, 2015). One of the more recently identified features of PD is heightened impulsivity (Averbeck, O'Sullivan, & Djamshidian, 2014). Several Impulsive control disorders (ICDs) frequently occur in PD, including pathological gambling, hypersexuality, compulsive shopping, dopamine dysregulation syndrome, and punding/hobbyism behaviours (Weintraub, David, Evans, Grant, & Stacy, 2015). The ability to correctly identify people with impulsive behaviours in PD is crucial for the management of these behaviours and for conducting valid research (Mestre, Strafella, Thomsen, Voon, & Miyasaki, 2013; Ramirez-Zamora, Gee, Boyd, & Biller, 2016).

Weintraub et al. (2012) developed the Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease Rating Scale (QUIP-RS) to screen for six ICDs that are commonly associated with PD. The QUIP-RS is considered to be one of the most valid and comprehensive measures of impulsive behaviours in PD (Evans et al., 2019). Measuring impulsive behaviours is challenging (Sharma, Markon, & Clark, 2014), especially in populations with neurodegenerative issues like PD. People with PD may have impaired insight, which could reduce their ability to accurately to self-report their own impulsive behaviours (Baumann-Vogel, Valko, Eisele, & Baumann, 2015). Furthermore, people with PD may be motivated to hide their impulsive behaviours due to the potentially embarrassing nature of these behaviours (Weintraub et al., 2015). This research explored the challenges associated with measuring impulsivity in PD, and investigated potential solutions to overcome these challenges.

Study one examined whether people with PD (n = 66) engage in alternative impulsive behaviours beyond the six ICDs that are assessed by the QUIP-RS (Weintraub et al., 2012). It was predicted that the QUIP-RS might be limited by its focus on specific ICDs, and that the participants' scores on QUIP-RS would not relate to engagement in other impulsive behaviours such as alcohol consumption, drug taking, reckless behaviours, and aggression. Study one also investigated whether using a more general measure like the BIS/BAS scale might be a viable alternative to the QUIP-RS. The results of a hierarchical multiple regression revealed

that the QUIP-RS was the only measure that independently predicted variability in the participants' engagement in the alternative impulsive behaviours ($\beta = .47$, $p < .001$). The BIS/BAS scale did not. The results demonstrated that the QUIP-RS is not limited by its focus on a few ICDs, but that scores on the QUIP-RS related to engagement in impulsive behaviours beyond those it directly screens for. As such, study one further validates the use of the QUIP-RS to assess impulsivity in PD, and suggests that the measure could be used as a more general indication of impulsive tendencies in PD. The results of study one also revealed that the BAS scales of the BIS/BAS scale had a positive relationship with the QUIP-RS, indicating that greater attraction to reward is associated with ICDs and other impulsive behaviours in PD.

Study two compared people with PD and an ICD (n = 32) to people with PD and no ICD (n = 34) in terms of their level of insight. It was expected that due to frontal impairments associated with impulsivity (Bickel, Jarmolowicz, Mueller, Gatchalian, & McClure, 2012; Sharma et al., 2014), people with ICDs in PD would have reduced insight compared to those without ICDs (Mack et al., 2013). The results indicated that the insight score for the ICD group ($M = .47$, $SD = 4.83$) was significantly higher than the no ICD group ($M = -2.09$, $SD = 3.84$), $t(64) = 2.39$, $p = .02$, $d = .59$. While unexpected, these results are in line with a similar study by Mack et al. (2013), and suggest people with ICDs in PD have better insight than those with no ICD. Study two also examined whether a participant's level of insight moderated the relationship between their self-reported impulsivity and engagement in impulsive behaviours. It was predicted that lower insight would reduce the relationship between self-reported impulsivity and engagement in impulsive behaviours. The interaction terms for the moderation models were non-significant, demonstrating that insight did not have a moderating effect. Therefore, the ability to successfully self-report impulsive tendencies in PD does not appear to be dependent on a person's level of insight.

Study three explored whether behavioural impulsivity tasks predicted engagement in impulsive behaviours in PD, and could therefore be used as a means to examine impulsivity in PD while overcoming the shortcomings of self-report measures (Enticott & Ogloff, 2006). The three behavioural tasks (Iowa Gambling Task, Balloon Analogue Risk Task, and the Probabilistic Reward Task) did not demonstrate a relationship with the participants' (n = 66) engagement in impulsive behaviours independently or when aggregated together. Study three also investigated

whether the behavioural impulsivity tasks would demonstrate a relationship with self-reported measures of impulsivity (QUIP-RS and BIS/BAS scale). No relationship was observed between the behavioural tasks and the self-report measures. Finally, study three tested moderation models to determine whether insight moderated the relationship between a participant's performance on the behavioural tasks and their self-reported impulsivity, such that a higher level of insight would strengthen the relationship. Insight did not moderate the relationship between any of the self-reported impulsivity measures and an overall score for the behavioural tasks. The findings of study three raise concerns about the validity of using these behavioural impulsivity tasks in PD, and suggest that any inferences made using behavioural impulsivity tasks in PD should be treated with caution.

Study four examined the utility of asking family/friends of people with PD to report on the impulsiveness of the person with PD. Informant (n = 64) and PD participant (n = 64) responses to the QUIP-RS were compared to determine their level of agreement on the six ICDs assessed by the QUIP-RS. Similar to a study by Papay et al. (2011), levels of agreement on gambling and sexual ICDs were moderate, but agreement was poor for the remaining behaviours assessed by the QUIP-RS (eating, shopping, and punding/hobbyism). These results suggest that when screening for the presence of impulsive gambling or sexual behaviours, both the informants' and PD participants' responses to the QUIP-RS can be used with a reasonable degree of confidence. Participant and informant responses to the QUIP-RS were then compared to the participants' engagement in several impulsive behaviours using two moderation models. The moderating variable was a discrepancy score (PD participant QUIP-RS score– informant QUIP-RS score). It was predicted that that a higher discrepancy score would (i) increase the relationship between informant reported impulsivity and the engagement in impulsive behaviours and (ii) decrease the relationship between self-reported impulsivity and the engagement in impulsive behaviours. This would suggest that when the informant and the person with PD disagree, the nominated informant's appraisal of impulsivity more accurately reflects engagement in impulsive behaviours, and the self-reported impulsivity less accurately reflects engagement in impulsive behaviours. The results revealed that informants' ($\beta = .18$, $p < .001$) and PD participants' ($\beta = .19$, $p < .001$) scores were associated with engagement in impulsive behaviours, but there was only a trend toward significant moderating effect in the second model. This suggests that

when PD participants considered themselves to be substantially more impulsive than their informants did, their self-reported impulsivity demonstrated a weaker correlation with their own engagement in impulsive behaviours.

Overall, this research had several important findings for measuring impulsivity in PD. The research demonstrated that the QUIP-RS is a valid measure for indicating that a person with PD is engaging in impulsive behaviours beyond the six ICDs that it screens for, and that the QUIP-RS appears to be equally valid whether it is completed by a person with PD or their informant. Furthermore, higher scores on the QUIP-RS also appear to be driven by a greater attraction to reward. Contrary to the concerns of some researchers (Baumann-Vogel et al., 2015; Mack et al., 2013), people with PD and ICDs do not appear to have impaired insight. Additionally, lower levels of insight do not seem to affect the ability of people with PD to self-report their impulsive behaviours. Lastly, although behavioural impulsivity offer several advantages over self-report assessments (Sharma et al., 2014), they may not be a valid means to assess impulsivity in PD

Glossary of Abbreviations

ADHD	Attention Deficit Hyperactivity Disorder
BART	The Balloon Analogue Risk Task
BAS	Behavioural Activation System
BCIS	Beck Cognitive Insight Scale
BIS	Behavioural Inhibition System
BIS/BAS Scale	Behavioural Inhibition System/Behavioural Activation system Scale
DA	Dopamine Agonist
DSM-5	Diagnostic and Statistical Manual of Mental Disorders, 5th Edition
ICD	Impulse Control Disorder
IGT	Iowa Gambling Task
L-Dopa	Levodopa
MIDI	Minnesota Impulsive Disorders Interview
PD	Parkinson's Disease
PRT	Probabilistic Reward Task
PWA	Parkinson's Western Australia
QUIP	Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease
QUIP-RS	Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease – Rating Scale
SERB	Screening for Risky Behaviours Battery
TICS-30	Telephone Interview for Cognitive Status-30
UPDRS	Unified Parkinson's Disease Rating Scale

Chapter 1Parkinson's Disease

1.1 Introduction

Parkinson's disease (PD) is one of the most common neurodegenerative conditions in the world, second only to dementia (Elbaz, Carcaillon, Kab, & Moisan, 2016). PD is associated with a range of motor and non-motor symptoms (Kalia & Lang, 2015), which significantly affect the lives of people with PD (Elmer & Hauser, 2011). As demographics shift worldwide towards an increasing proportion of older adults, the prevalence of PD is expected to grow (Dorsey et al., 2006). The economic burden of PD in the United States is estimated to be $14.4 billion USD per annum (Kowal, Dall, Chakrabarti, Storm, & Jain, 2013), 13.9 billion Euros per annum in Europe (Olesen et al., 2012), and $1.1 billion in Australia (Deloitte Access Economics, 2015). Health systems in developing nations are also expected to be increasingly challenged by the rising costs associated with PD (Schapira & Tan, 2012).

James Parkinson (1817) first formally identified the cardinal motor features of PD such as tremor, impaired gait, and bradykinesia (Goetz, 2011). Subsequent research has since described the range and heterogeneity of motor symptoms observed in PD (Goetz, 2011). It is now also recognised that PD involves a number of non-motor symptoms that can be just as debilitating as the motor symptoms (Elmer & Hauser, 2011). Issues such as sleep disturbance, cognitive impairment, anxiety, depression, and impulsive behaviours have all been linked to PD (P. Martinez-Martin et al., 2015).

Greenfield and Bosanquet (1953) developed one of the first comprehensive accounts of PD pathology which highlighted the loss of dopaminergic cells in the substantia nigra. Braak, Del Tredici, et al. (2003) have since developed a staging framework to explain how PD progresses through the brain. Their account of PD pathology is now widely accepted, and explains how misfolded proteins propagate through the brain in a predictable fashion, causing the degeneration of neurons in numerous areas. PD research now recognises that the pathology of PD affects several different neurotransmitter systems, and is far more complex than the degeneration of dopaminergic systems in isolation (Halliday, 2012).

1.2 Pathogenesis of PD (Braak's Hypothesis)

The diagnosis of PD requires the presence of cell death in the substantia nigra (particularly the pars compacta) and Lewy pathology (Dickson, Braak, et al., 2009). Lewy pathology refers to misfolded proteins, either in the form of Lewy bodies or Lewy neurites (Del Tredici & Braak, 2012). These misfolded proteins are primarily the result of the protein α-synuclein (Del Tredici & Braak, 2012). A-synuclein naturally exists within the brain in abundant quantities and is generally located near the presynaptic terminal of neurons (Bendor, Logan, & Edwards, 2013). In PD, these proteins accumulate into insoluble masses (Lewy bodies and Lewy neurites) which interfere with the normal functioning of cells (Bonini & Giasson, 2005). Lewy bodies sequester enzymes within the neuron, resulting in a deficit of enzymes that are needed to effectively produce neurotransmitters (Dugger & Dickson, 2010). These protein aggregates are also thought to contribute to neuronal dysfunction and eventually the death of the neuron (Del Tredici & Braak, 2012). Why α-synuclein accumulates in this manner remains unclear, but the failure of mechanisms in the cell responsible for clearing abnormal proteins has been proposed (Pan, Kondo, Le, & Jankovic, 2008). The composition of lipids in the cell might also play a role, as the presence of certain lipids have been shown to accelerate the accumulation of these proteins (Grey et al., 2015).

Braak, Del Tredici, et al. (2003) proposed that idiopathic PD follows a predictable path, whereby Lewy pathology lesions form in vulnerable areas in a systematic fashion, while non-vulnerable areas are left relatively unaffected. This idea is referred to as Braak's hypothesis (Rietdijk, Perez-Pardo, Garssen, van Wezel, & Kraneveld, 2017). Braak's hypothesis proposes that the progression of the Lewy pathology is determined by the neurons that are susceptible to developing these protein aggregates. Neurons prone to Lewy pathology have two shared characteristics. Firstly, they have axons that are long and thin in relation to the soma of the neuron. Secondly, vulnerable neurons have poor or no myelination along their axons. In contrast, neurons with short, well myelinated axons do not develop Lewy pathology, even when they are in close proximity to affected neurons.

Braak, Del Tredici, et al. (2003) explain the pathogenesis of PD in six stages. The process begins with a pathogen that triggers the misfolding of α-synuclein (Braak, Rüb, Gai, & Del Tredici, 2003). The misfolded α-synuclein proteins then

progress through the nervous system across susceptible neurons in a prion-like fashion. At stage one, lesions appear in both the olfactory bulb and the dorsal motor nucleus of the vagus nerve. The lesions do not extend beyond the olfactory bulb as this area is surrounded by neurons that are resistant to Lewy pathology, but they do continue to progress from the vagus nerve to the cerebral cortex (reaching the cortex at stage five). At stage two, lesions move into the brainstem and appear in the lower raphe nuclei and reticular formation. These areas are important for the serotonergic, cholinergic, and noradrenergic neurotransmitter systems (Jellinger, 2012). Disruptions to these systems are thought to impair frontal areas of the brain, potentially contributing to heightened impulsivity in PD (Gratwicke, Jahanshahi, & Foltynie, 2015). Neurons in these areas are sparsely myelinated, making them susceptible to α-synuclein pathology (Braak, Rüb, et al., 2003). Importantly, the person with PD would still be asymptomatic in terms of motor symptoms at this stage. During stage three, lesions appear in limbic areas and the first lesions are observed in the substantia nigra. Lesions also continue to develop in previously affected areas. Lewy neurites are the first lesions to form, but as the disease progresses Lewy bodies also appear. In stage four, the α-synuclein pathology reaches the forebrain and the temporal mesocortex is affected. The temporal mesocortex has strong connections with limbic areas, and it is proposed that these connections allow the α-synuclein pathology to travel from limbic to cortical areas. It is around stage three or four that the motor symptoms of PD will manifest as Lewy pathology lesions to dopaminergic neurons in the substantia nigra become more severe. The resulting impairment of dopaminergic functioning likely affects reward learning, furthering the development of impulsivity issues (Cossu, Rinaldi, & Colosimo, 2018). In stages five and six Lewy pathology appears in the neocortex. Prefrontal areas are initially affected, but in the late stages of PD Lewy pathology extends to the primary sensory and motor areas. In these later stages, frontal areas of the cortex are affected by Lewy pathology. As these areas are thought to be related to the inhibition of impulsive urges, associated behaviours might be impacted (Bickel et al., 2012).

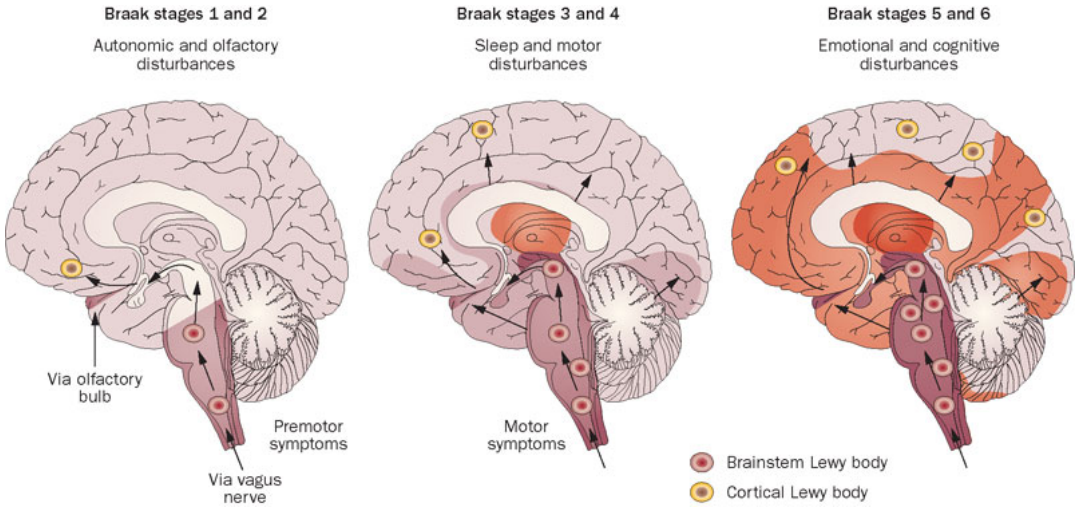

Figure 1.1 The progression of Parkinson's Disease pathology according to Braak's hypothesis.
Taken from (Doty, 2012b)

1.3 Dual hit hypothesis

Hawkes, Del Tredici, and Braak (2007) expanded Braak's hypothesis in their 'Dual Hit Hypothesis', to explain how the misfolding of α-synuclein might be triggered. The Dual Hit Hypothesis suggests that an unknown pathogen enters the nervous system at two different sites. As previously stated, the olfactory bulb and dorsal motor nucleus of the vagus nerve are the first regions to be affected in PD. In accordance with the dual hit hypothesis, it is thought that a pathogen invades the olfactory bulb though the nasal passages and simultaneously enters the enteric nervous system via the digestive tract. The pathology then progresses along the vagus nerve in a prion-like manner, eventually reaching the dorsal motor nucleus in the brain stem (stage 1 of Braak's hypothesis).

Although Braak's hypothesis is widely accepted, it is has been criticised on a number of points (Halliday, McCann, & Shepherd, 2012). To test Braak's hypothesis, Kalaitzakis, Graeber, Gentleman, and Pearce (2008) examined brain samples from 71 people who had a diagnosis of PD during their lifetime. They inspected α-synuclein aggregates to establish whether they fitted the pattern proposed by Braak, Rüb, et al. (2003). The results revealed that for 7% of cases, the dorsal motor nucleus of the vagus nerve was unaffected. This finding is inconsistent with Braak's hypothesis. Furthermore, the authors concluded that only 53% of the brain samples strictly aligned with the staging system of Braak's hypothesis. A sample

would be rejected as not fitting Braak's hypothesis if, for example, severe α-synuclein pathology was found in the substantia nigra and the dorsal motor nucleus was relatively unaffected. Although this casts doubt upon the Braak's hypothesis, a couple of points must be considered. Firstly, Lewy pathology is associated with many other neurodegenerative disorders, which may have been misdiagnosed as PD or be co-morbid with PD (Halliday et al., 2012). This could account for the unexpected α-synuclein pathology in some PD cases (Halliday et al., 2012). Secondly, familial (genetically based) forms of PD can present with atypical pathologies in the brain (Dickson, 2017), which may explain why some cases in the Kalaitzakis et al. (2008) study were inconsistent with Braak's hypothesis.

In a review of Braak's hypothesis, Rietdijk et al. (2017) argued that, despite criticisms, there is a large body of research supporting the proposed staging system. Braak, Rüb, et al. (2003) stated that the first areas to be affected by PD are the olfactory blub, enteric nervous system, and dorsal motor nucleus of the vagus nerve. Therefore, it would be expected that olfactory issues and gastrointestinal issues will precede motor symptoms in PD. Olfactory issues have been shown to precede motor symptoms of PD (Haehner et al., 2007; Ross et al., 2008), and are present in more than 90% of PD cases (Doty, 2012a). Similarly, gastrointestinal issues have also been reported prior to the presentation of motor symptoms of PD (Cersosimo et al., 2013). Gastrointestinal issues in PD are thought to be associated with Lewy bodies and Lewy neurites which form in the enteric nervous system (around the gut), and the dorsal motor nucleus of the vagus nerve (Lebouvier et al., 2010). Rietdijk et al. (2017) concluded that whilst Braak's hypothesis may not be consistent with all PD cases, it remains the most comprehensive account of PD pathogenesis. Given that Braak's hypothesis is the best account of PD pathogenesis available, it is reasonable to suggest that for most PD cases the Lewy pathology will progress from the brainstem, up to limbic areas, before reaching the neocortex. It is therefore reasonable to predict the neurotransmitter systems which originate from the brain stem (serotonergic, cholinergic, and noradrenergic) will be affected in the earlier stages of PD. Furthermore, Lewy pathology can be expected in cortical areas (including pre-frontal areas) in the later stages of PD.

1.4 Neurotransmitter systems affected in PD

The classic view of PD is that it results from the loss of dopaminergic neurons (Halliday, 2012). Research has now established that PD is more complex than the degeneration of dopaminergic neurons alone (Barone, 2010). While older research (20+ years) identified that non-dopaminergic neurotransmitters are affected in PD, it is only relatively recently that researchers have started to examine how these other systems might contribute to PD symptoms (Halliday, 2012). PD is now thought to affect dopaminergic, cholinergic, serotoninergic, and noradrenergic systems in the brain, which contributes to both the motor and non-motor symptoms observed in PD (Barone, 2010; Kehagia, Barker, & Robbins, 2013).

1.4.1 Dopaminergic system

The basal ganglia plays an important role in the cardinal motor symptoms of PD (Moustafa et al., 2016). The basal ganglia is crucial for the normal execution of movement, forming a network with the thalamus and the cortex to allow a person to perform voluntary movements (Blandini, Nappi, Tassorelli, & Martignoni, 2000; Galvan & Smith, 2010; Mandir & Vaughan, 2000). Specifically, the basal ganglia plays an important role in moderating the magnitude of voluntary movements (Blandini et al., 2000; Galvan & Smith, 2010). The main components of the basal ganglia are as follows: The dorsal striatum (the caudate nucleus and putamen), the ventral striatum (nucleus accumbens), the subthalamic nucleus, the globus pallidus, the ventral tegmental area, and the substantia nigra (Galvan & Smith, 2010).

The ‘rate model’ seeks to explain how the basal ganglia assists voluntary movement (Nelson & Kreitzer, 2014). The rate model proposes that two major pathways exist in the basal ganglia, a direct pathway and an indirect pathway (Nelson & Kreitzer, 2014). Excitatory projections from the cortex feed into the dorsal striatum (Braak & Del Tredici, 2008). The dorsal striatum transmits this information through the direct and indirect pathways to the ‘output nuclei’ of the basal ganglia, which are the substantia nigra pars reticulata and the medial globus pallidus (Blandini et al., 2000). In the direct pathway, the dorsal striatum connects straight to the output nuclei (Blandini et al., 2000). In the indirect pathway, the dorsal striatum connects to the lateral globus pallidus, which has bi-directional connections to the subthalamic nucleus (Blandini et al., 2000). The subthalamic nucleus then

connects to the output nuclei (Blandini et al., 2000). For both pathways the output nuclei then connect to the thalamus, which relays information back to the cortex to execute movements (Nelson & Kreitzer, 2014). The direct pathway inhibits the output nuclei which results in the excitation of the thalamus (as the output nuclei have an inhibitory effect on the thalamus; DeLong & Wichmann, 2009). In contrast, the indirect pathway excites output nuclei which has an inhibitory effect on the thalamus (DeLong & Wichmann, 2009). The successful execution of moments results from an equilibrium between these two pathways (Braak & Del Tredici, 2008).

Movement in PD is affected as dopaminergic cells in the substantial nigra pars compacta die, resulting in a lack of dopamine in the nigrostriatal pathway (part of the dorsal striatum; Dickson, 2017; Jellinger, 2012). This causes a number of functional changes to occur within the basal ganglia, resulting in the motor symptoms observed in PD (Blandini et al., 2000). The lack of dopamine in the striatum causes in imbalance between the direct and indirect pathways (Braak & Del Tredici, 2008). For the direct pathway, the lack of dopamine in the dorsal striatum results in less inhibition of the output nuclei. Consequently, these nuclei exert greater inhibitory control over the thalamus (Lewis & Barker, 2009). For the indirect pathway, the lack of inhibition from the dorsal striatum leads to over-activation of the subthalamic nucleus. Like the changes to the direct pathway, this leads to an over activation of the output nuclei and inhibition of the thalamus (Lewis & Barker, 2009). Inhibition of the thalamo-cortical activity caused by changes to these pathways results in the cardinal motor symptoms observed in PD (Braak & Del Tredici, 2008). Whilst this account is widely accepted as the primary explanation of PD motor symptoms, most researchers acknowledge that different cortical systems and a range of neurotransmitters also contribute (Braak & Del Tredici, 2008; Nelson & Kreitzer, 2014). It is worth noting that the damage to dopaminergic functioning in the basal ganglia (particularly the ventral striatum) observed in PD has been implicated in the development of impulsive behaviours (Averbeck et al., 2014). This is discussed in more detail in chapter two.

1.4.2 Serotoninergic system

The raphe nuclei are located on the brain stem and primarily contain serotonergic neurons (Hornung, 2003). There are two main serotonergic projections

that originate from the raphe nuclei, the rostal group and the caudal group (Hornung, 2003). The rostal group projects to the forebrain, innervating areas such as the hypothalamus, basal ganglia, amygdala (Politis & Niccolini, 2015). The rostal projections then continue upwards to the lateral and medial areas of the cortex (Hornung, 2003). The caudal group is the smaller of the two pathways and projects to the brain stem (Politis & Niccolini, 2015). In stage two of Braak's hypothesis, α-synuclein pathology reaches the raphe nuclei (Braak, Rüb, et al., 2003). However, research examining the degeneration of the raphe nuclei in PD has yielded mixed results (Kish et al., 2008; Qamhawi et al., 2015).

Research has established that overall serotonin levels are reduced in people with PD. Kish et al. (2008) examined the brain samples of 23 people who had a diagnosis of PD during their lifetime. Testing for markers of serotonin, Kish et al. (2008) examined whether PD samples demonstrated reduced serotonin compared control samples. The results revealed that the PD samples had reduced serotonin markers in a number of areas, including the basal ganglia, frontal lobe, hippocampus, and the thalamus. Kish et al. (2008) stated that whilst it might be expected that the reduced serotonin observed in PD is due to the degeneration of the raphe nuclei, a number of studies have not provided evidence to support this.

Politis et al. (2010) sought to establish whether depleted serotonin in PD is due to the loss of serotonergic neurons in the raphe nuclei. Braak's hypothesis predicts that the raphe nuclei should show decreased serotonin due to α-synuclein pathology around stage two. Using *in vivo* imaging techniques, Politis et al. (2010) examined 30 participants with PD and compared them to controls (matched for age and gender). Only participants in the advanced stages of PD (10+ years since diagnosis) demonstrated reduced serotonergic function in the raphe nuclei. The authors concluded that their results did not support the idea that the raphe nuclei are affected early in PD, and were therefore inconsistent with Braak's hypothesis. Qamhawi et al. (2015) recently conducted a more comprehensive study involving 345 participants with PD to examine whether the raphe nuclei are affected in early PD (less than two years since diagnosis). Using *in vivo* imaging techniques they found that the number of serotonergic neurons was significantly lower in the raphe nuclei for 12.5% of PD participants compared to controls (matched for age and gender). This means that according to the imaging methods used, the majority (87.5%) of the PD sample had relatively intact serotoninergic structures in the raphe

nuclei. The authors argued that although the raphe nuclei seem to be relatively unaffected in early PD, this is not necessarily inconsistent with Braak's hypothesis. A-synuclein pathology could target neuron terminals in the raphe nuclei rather than cell bodies, an idea also proposed by Kish et al. (2008). Qamhawi et al. (2015) noted that the current imaging techniques that they employed would not be able to detect damage to the actual nerve terminals. Given that α-synuclein is generally located at the terminals of neurons (Bendor et al., 2013), this argument has some merit. The authors concluded that whilst α-synuclein pathology observed by Braak, Del Tredici, et al. (2003) could affect the nerve terminals of the raphe nuclei, it is unlikely that PD causes significant lesions to serotonergic neurons in the raphe nuclei until the later stages of PD pathology.

Taken together, the findings of these studies indicate that it is unclear how α-synuclein pathology affects the raphe nuclei and, correspondingly, serotonin levels in PD. Nevertheless, there is a large amount of evidence that demonstrates reduced serotonin levels in PD (Bohnen & Albin, 2011; Kish et al., 2008; Politis & Niccolini, 2015). The reduced serotonin levels observed in PD are thought to contribute to depression, anxiety, pain, constipation, fatigue, sleep disturbances, obsessive behaviours, and cognitive impairment (Barone, 2010; Politis & Niccolini, 2015). Additionally, serotonin has been linked to tremors and dyskinesia (involuntary movement of the limbs) in PD (Politis & Niccolini, 2015; Qamhawi et al., 2015).

1.4.3 Cholinergic system

Acetylcholine is the primary neurotransmitter of the cholinergic system, which has been linked to cognitive functioning and motor coordination (Hrabovska & Krejci, 2014). There are two main cholinergic projections in the brain, a subcortical system and a cortical system (Rochester et al., 2012). The pedunculopontine complex is where the subcortical system originates (Bohnen & Albin, 2011). Afferent projections from here primarily connect to the thalamus, with smaller connections innervating the brainstem and cerebellum (Bohnen & Albin, 2011). A cortical system originates from the basal forebrain (including the nucleus basalis of Meynert) and projects to the cerebral cortex (Müller & Bohnen, 2013). In the third stage of Braak's hypothesis, α-synuclein pathology reaches these areas (Braak, Del Tredici, et al., 2003). Correspondingly, early research reported the loss of cholinergic neurons in the nucleus basalis of Meynert and the cortex in PD (Perry

et al., 1985; Tagliavini, Pilleri, Bouras, & Constantinidis, 1984; Whitehouse, Hedreen, White, & Price, 1983)

More recent research has examined markers of acetylcholine using *in vivo* imaging techniques. Gilman et al. (2010) compared participants with PD to a control group to determine whether there was a difference in acetylcholine markers in cortical and sub-cortical areas. The results demonstrated that participants with PD had reduced acetylcholine in a number of subcortical regions, including the thalamus. This indicates that the pedunculopontine subcortical projections are potentially affected in PD (Müller & Bohnen, 2013). The results also revealed that the cortex of PD participants had significantly less acetylcholine compared to the control group. This implies that the cortical pathways from the nucleus basalis of Meynert are also affected in PD. It is thought that in PD the death of cells in the nucleus basalis of Meynert underlie reduced cholinergic levels in the cortex (Barone, 2010). These results are consistent with a number of imaging studies revealing cholinergic deficits in PD (Hilker et al., 2005; Shimada et al., 2009). Whilst cholinergic deficits are commonly observed in PD, there is a significant degree of heterogeneity in the extent of cholinergic denervation (Bohnen et al., 2012)

One of the primary symptoms associated with cholinergic deficits in PD is cognitive impairment (Barone, 2010). Hilker et al. (2005) reported that PD participants with dementia had a 30% global reduction in acetylcholine compared to controls, whereas PD participants without dementia had a global acetylcholine reduction of 11%. Issues with balance and gait have also been associated with cholinergic changes in PD (Gilman et al., 2010; Rochester et al., 2012). Lower levels of acetylcholine are associated with postural and gait difficulties, which might explain why these symptoms are generally less responsive to dopaminergic treatments (Müller & Bohnen, 2013). While issues with cognition and gait are the main problems associated with cholinergic changes in PD, complications with olfaction and depressive symptoms are also thought to be linked to cholinergic denervation (Bohnen & Albin, 2011).

1.4.4 Noradrenergic system

There are two main noradrenergic systems, both originating from the brain stem (Gesi et al., 2000). One system projects from the medulla oblongata and the other from the pons (Gesi et al., 2000). These systems provide the brain with the

neurotransmitter noradrenaline (also known as norepinephrine; Halliday, 2012). According to Braak's hypothesis, α-synuclein pathology reaches the brainstem before the substantia nigra (during stage two), and as such the noradrenergic system should be affected before the dopaminergic system in PD (Del Tredici & Braak, 2013). The locus coeruleus is a nucleus in the pons and is the primary source of noradrenergic innervation in the human brain (Del Tredici & Braak, 2013). Research has confirmed neuronal loss in locus coeruleus is associated with PD (McMillan et al., 2011; Zarow, Lyness, Mortimer, & Chui, 2003). There is also some evidence to suggest that the degeneration of the locus coeruleus occurs early in PD pathology (Del Tredici & Braak, 2013).

Pavese, Rivero-Bosch, Lewis, Whone, and Brooks (2011) compared recently diagnosed PD participants against controls for markers of noradrenaline at baseline, and again three years later. The groups did not show significant differences in markers of noradrenaline at baseline. However, at the three year follow up, the PD group demonstrated a significant (18%) decrease in noradrenaline markers in the locus coeruleus. The authors concluded that this finding likely reflects the progressive loss of noradrenergic function in PD. Pifl, Kish, and Hornykiewicz (2012) investigated how the level of noradrenaline changes in the thalamus for people with PD. The locus coeruleus has noradrenergic projections that have a strong influence over the thalamus (Pifl et al., 2012). As previously mentioned, the thalamus sends information to the cortex to execute movements (Nelson & Kreitzer, 2014). Pifl et al. (2012) reported that participants with PD had severely reduced levels of noradrenaline in the thalamus. It was suggested that this was due to the degeneration of the locus coeruleus in PD. These findings are significant, as they suggest that the focus on dopaminergic changes influencing thalamic activity may overlook the important role of systems like the noradrenergic system (Halliday, 2012).

The loss of noradrenaline in PD is thought to contribute to a number of symptoms in PD (Barone, 2010). Reduced noradrenaline in PD weakens cognitive abilities dependent on frontal areas, and as a result, people with PD are less able to inhibit impulsive behaviours. (Del Tredici & Braak, 2013; Kehagia et al., 2014). Decreased noradrenaline is also thought to contribute to depression in PD (Remy, Doder, Lees, Turjanski, & Brooks, 2005). Given the connections between the locus coeruleus and the thalamus, it is not surprising that depleted noradrenaline is also

thought to contribute to PD motor symptoms (Del Tredici & Braak, 2013). Motor symptoms such as tremor, freezing, and postural instability have been linked to the noradrenergic system (Gesi et al., 2000). The loss of noradrenergic neurons is also thought to exacerbate the progression of PD, as noradrenaline purportedly has a neuroprotective role (Rommelfanger & Weinshenker, 2007). It has been proposed that the loss of noradrenaline neurons in PD may therefore hasten the loss of dopaminergic neurons (Rommelfanger & Weinshenker, 2007).

It is clear that PD pathology is more complex than the degeneration of dopaminergic neurons alone. A number of different neurotransmitters and systems are involved in PD, all of which are affected to some extent. The neurotransmitters involved have a complex relationship, in that they do not act separately, but influence and modulate different areas of the brain in an interdependent manner (Barone, 2010). Perhaps this is why it is difficult to decipher the precise role that each neurotransmitter plays, and why they all contribute to the range of symptoms observed in PD.

1.5 Motor symptoms of PD

A range of motor symptoms are associated with PD (Moustafa et al., 2016). Both the UK PD Brain Bank criteria and Movement Disorder Society diagnostic criteria specify the cardinal motor symptoms of PD as being bradykinesia, rest tremor, and rigidity (Hughes, Daniel, Kilford, & Lees, 1992; Postuma et al., 2015). Issues such as speech disturbances, dystonia, dyskinesia, gait impairments, and difficulties with fine motor control are also observed in PD (Moustafa et al., 2016; Sveinbjornsdottir, 2016). Most PD motor symptoms are associated with the dopaminergic changes that occur in PD, however some may occur as a consequence of dopamine replacement therapies such as Levodopa (L-Dopa; Sveinbjornsdottir, 2016). Whilst there are core symptoms of PD, the presentation of these symptoms can vary greatly. For example, 30% of people with PD do not present with tremor (Helmich, Hallett, Deuschl, Toni, & Bloem, 2012; Lewis & Barker, 2009). The heterogeneity of motor symptoms in PD has led researchers to categorise PD into different subtypes (Thenganatt & Jankovic, 2014). Two main subtypes are commonly recognised in the literature, (1) a tremor dominant PD subtype, and (2) a postural instability plus gait difficulty subtype (Thenganatt & Jankovic, 2014).

Bradykinesia refers to slowness in performed movements, a delay in initiating movements, and decreased amplitude/speed of repeated movements (Jankovic, 2008). Bradykinesia is the primary symptom of PD, and must be present for a diagnosis of PD according to the UK PD Brain Bank criteria and the Movement Disorder Society diagnostic criteria (Hughes et al., 1992; Postuma et al., 2015). Bradykinesia manifests in a number of ways, such as issues with handwriting, impairments in fine motor control, masked facial expressions, decreased blinking, and reduced arm swing whilst walking (Jankovic, 2008). Bradykinesia in PD is due to muscles being under-recruited, resulting in the person 'undershooting' their movements (Berardelli, Rothwell, Thompson, & Hallett, 2001). Disruption to the basal ganglia in PD (in particular a lack of dopamine in the dorsal striatum) is thought underlie bradykinesia, as the basal ganglia helps moderate the amplitude of movements (Berardelli et al., 2001; Moustafa et al., 2016).

Rigidity is a stiffness of the muscles and is characterised by a resistance to passive movement (Postuma et al., 2015). The 'cogwheel' phenomenon can be present in PD as a result of rigidity (Jankovic, 2008). Cogwheeling is when a person demonstrates jerky rather than fluid movements, and is often accompanied by tremor (Jankovic, 2008). Rigidity in PD can be present in a number of areas, including the neck, hip, wrists, and shoulders (Jankovic, 2008). The neural mechanisms underlying rigidity in PD are unclear (Baradaran et al., 2013). Like bradykinesia, the basal ganglia has been implicated in rigidity, specifically the subthalamic nucleus (Tabbal et al., 2008). Results regarding the role of the basal ganglia are, however, mixed (Baradaran et al., 2013). The general consensus is that rigidity involves a widespread neural network involving both cortical and sub cortical areas (Baradaran et al., 2013; Moustafa et al., 2016)

Resting tremor in PD is an involuntary 4-6 Hz tremor that is present in a resting limb (i.e., disappears when the limb is moved), and generally affects the hands and feet (Moustafa et al., 2016; Postuma et al., 2015). Kinetic tremor can also be present in PD, whereby tremor occurs when the limb is being voluntarily moved (Moustafa et al., 2016). The subthalamic nucleus, pallidum, and ventral lateral thalamus (all located in the basal ganglia) are thought to underlie tremor in PD (Helmich et al., 2012). Neurons in these areas have been found to fire at the same rate as the observed tremor itself (Helmich et al., 2012). The cerebellum, thalamus, and cortical areas are also thought to play a role in PD tremor (Helmich et al., 2012).

Benninger, Thees, Kollias, Bassetti, and Waldvogel (2009) found that people with PD with a tremor have reduced grey matter in the cerebellum compared to those with no tremor. Furthermore, decreased serotonin in PD has also been linked to increased tremor severity (Qamhawi et al., 2015). Overall, the neural mechanisms behind tremor are not comprehensively understood, but disruptions to numerous cortical structures have been implicated (Moustafa et al., 2016).

1.6 Non-motor symptoms of PD

PD has typically been characterised as a motor disorder, with only a few authors noting non-motor symptoms in the first 150 years after PD was first described by James Parkinson (Garcia-Ruiz, Chaudhuri, & Martinez-Martin, 2014). However, non-motor symptoms are now acknowledged as being a substantial aspect of PD, and are known to contribute significantly to the burden of PD for both the person with PD and their peers (Chaudhuri et al., 2015). Non-motor symptoms of PD have been shown to have a greater negative impact on quality of life than motor symptoms (Martinez-Martin, Rodriguez-Blazquez, Kurtis, & Chaudhuri, 2011; Prakash, Nadkarni, Lye, Yong, & Tan, 2016). Some non-motor symptoms precede the motor symptoms of PD, such as sleep disturbances and gastrointestinal disorders (Jellinger, 2015). Conversely, non-motor symptoms like cognitive impairment and executive dysfunction typically arise later in the disease progression (Jellinger, 2015). The onset of non-motor symptoms is thought to be associated with the progression of PD, with different symptoms arising as Lewy pathology travels through the relevant areas of the brain (Jellinger, 2015).

1.6.1 Sleep disturbances

Estimates regarding prevalence of sleep issues in PD range from 65-95% (Louter, Aarden, Lion, Bloem, & Overeem, 2012). The main sleep disturbances associated with PD include excessive daytime sleepiness, insomnia, and REM sleep behaviour disorder (Jellinger, 2015). Sleep may also be impacted by the motor symptoms of PD, such as experiencing difficulty turning in bed or needing to urinate frequently during the night (Louter et al., 2012). Sleep disturbances can precede PD motor symptoms by more than a decade, and are thought to be a consequence of early α-synuclein pathology (Claassen et al., 2010). Both cholinergic and

noradrenergic neurons in the brain stem are necessary for regulating sleep (Grinberg, Rueb, Alho, & Heinsen, 2010). These structures are affected early in PD pathology (stage one of Braak's hypothesis), which might explain why sleep issues can occur early in the disease (Jellinger, 2015).

1.6.2 Gastrointestinal and olfactory issues

As previously mentioned, the Dual Risk Hypothesis of PD suggests that a pathogen enters the body through the nasal passages and digestive tract (Hawkes et al., 2007). In line with the dual hit hypothesis, olfactory and gastrointestinal issues are commonly reported in PD and often precede the appearance of motor symptoms (Cersosimo et al., 2013; Doty, 2012a; Haehner et al., 2007). Olfactory issues are thought to be due to α-synuclein pathology in the olfactory blub, which occurs during the first stage of the Braak's hypothesis (Jellinger, 2015). Beach et al. (2008) found that 95% of people with PD had α-synuclein pathology in the olfactory bulb. A-synuclein pathology is also thought to be responsible for gastrointestinal complications in PD, being present in the both the enteric nervous system and the dorsal motor nucleus of the vagus nerve (Cersosimo & Benarroch, 2008). Excitatory and inhibitory pathways from the dorsal motor nucleus of the vagus nerve connect to the enteric nervous system, allowing for autonomic control of the gut via the brain stem (Cersosimo & Benarroch, 2008). A-synuclein pathology in these areas is thought to underlie gastrointestinal complications in PD, such as constipation (Jellinger, 2015).

1.6.3 Depression and anxiety

Depression is the most common neuropsychiatric issue associated with PD and contributes significantly to the burden of the disease (Tan, Hartung, Sharp, & Temel, 2011). Around 35% of people with PD have clinically significant depressive symptoms, and 17% meet the criteria for major depressive disorder (Reijnders, Ehrt, Weber, Aarsland, & Leentjens, 2008). This is significantly more than the rate of 2% observed in the general older adult population (Even & Weintraub, 2012). Greater levels of depression in PD could be due to stressors associated with the illness. However, comorbid depression in other chronic medical conditions is approximately 9% which is still significantly lower than the rate in PD (Even & Weintraub, 2012). This has led researchers to suggest that the neuropathology of PD likely plays a role

in the development of depression (Even & Weintraub, 2012). Neural degeneration in the cholinergic system associated with PD is thought to contribute to depression (Bohnen & Albin, 2011), in addition to the reduced levels of serotonin observed in PD (Politis & Niccolini, 2015). One of the main treatments for depression in PD is the administration of selective serotonin reuptake inhibitors which increase serotonin levels in the brain (Barone, 2010).

A recent systematic review estimated that 31% of people with PD experience an anxiety disorder (Broen, Narayen, Kuijf, Dissanayaka, & Leentjens, 2016). In comparison, the World Health Organisation estimates that 8% of the general population have an anxiety disorder (Broen et al., 2016). Whilst anxiety in PD can, in part, be attributed to associated stressors (e.g., fear of people staring in public), it is also thought that the neuropathology of PD contributes to the development of anxiety (Prediger, Matheus, Schwarzbold, Lima, & Vital, 2012). Anxiety has been linked to an increased risk of developing PD, which suggests that anxiety could be a pre-motor symptom of PD (Bower et al., 2010; Lin, Lin, Liu, Chang, & Wu, 2015). Anxiety in PD may be a consequence of early α-synuclein pathology driven by changes to neurotransmitter systems (Prediger et al., 2012). Disruptions to dopaminergic, serotonergic, and noradrenaline systems in PD are all thought to contribute to heightened anxiety (Pontone, 2017; Prediger et al., 2012). The amygdala and limbic areas play an important role in anxiety fear-related emotions, these areas are innervated by dopaminergic and serotonergic systems and the disruption of these symptoms in PD is thought to contribute to the development of anxiety disorders (Eskow Jaunarajs, Angoa-Perez, Kuhn, & Bishop, 2011; Prediger et al., 2012). Like the treatment of depression, selective serotonin reuptake inhibitors are also used to alleviate anxiety in PD by increasing the levels of serotonin in the brain (Prediger et al., 2012).

1.6.4 Cognitive impairment

Cognitive issues in PD can range from mild cognitive impairment to clinical dementia, and are a significant determinant of a person's functionality (Kehagia, Barker, & Robbins, 2010). Mild cognitive impairment represents the earliest clinically significant symptoms of cognitive decline (Jellinger, 2013). Mild cognitive impairment is present when a person has the ability to remain functionally independent in terms of their cognitive abilities, while presenting with deficits in one

or more of the following cognitive domains: attention and working memory, executive functioning, language, memory, and visuospatial ability (Litvan et al., 2012). PD dementia generally manifests in the latter stages of PD, around stage five of Braak's hypothesis (Dickson, Fujishiro, et al., 2009). PD dementia is defined as a slow decrease in cognitive abilities that affects more than one cognitive domain, with impairment severe enough to impact daily functioning irrespective of the motor symptoms present due to PD (Emre et al., 2007). It is at stage five that α-synuclein pathology reaches the cortex (Braak, Rüb, et al., 2003). Consistent with this, research has demonstrated that people with PD dementia have a 10 fold increase in Lewy body inclusions in the cortex compared to non-demented PD participants (Apaydin, Ahlskog, Parisi, Boeve, & Dickson, 2002).

Cognitive impairments can occur early in PD (Jellinger, 2015). In PD, mild cognitive impairment is estimated to affect up to 60% of people within the first five years of diagnosis, and has been identified as risk factor for later developing PD dementia (Kehagia et al., 2010; Lawrence, Gasson, & Loftus, 2016). Patterns of cognitive impairment in PD resemble clinical populations that have damage to prefrontal areas, cognitive domains that are commonly affected in PD include attention, working memory, planning, executive functions, and set-shifting abilities (Kehagia et al., 2010).

Whilst it is acknowledged that PD Lewy pathology impacts upon cognition, there are multiple mechanisms underlying the development of impaired cognition in PD (Jellinger, 2013). Dopaminergic deficits are thought to contribute to impaired cognition in PD (Gratwicke et al., 2015). Striatal dopaminergic pathways originate from the basal ganglia and project to frontal areas, which are important for higher order functions (Gratwicke et al., 2015). Reduced dopamine in the basal ganglia affects these pathways which disrupts the normal functioning of frontal areas (Kehagia et al., 2013). In PD, these striatal dopaminergic pathways are under activated during tasks which require higher order cognitive abilities, resulting in poorer task performance (Gratwicke et al., 2015). Lewis, Dove, Robbins, Barker, and Owen (2003) demonstrated that when completing a working memory task, PD participants with cognitive impairments had reduced activation in striatal pathways and frontal areas compared to age matched controls. As previously mentioned, the cholinergic system is also implicated cognitive impairment in PD (Silbert & Kaye, 2010). Global reductions in cholinergic markers have been linked to cognitive

decline in PD, and these reductions are more pronounced in people with PD and dementia compared to people with PD and mild cognitive impairment (Bohnen et al., 2006; Silbert & Kaye, 2010). As both cholinergic and dopaminergic systems are affected in the earlier stages of PD pathology, it makes sense that cognitive impairment can be observed before α-synuclein pathology reaches the cortex (in the later stages of PD).

1.6.5 Impulsive behaviours

Increased impulsive behaviours have been reported in PD (Averbeck et al., 2014). Approximately 13% of people with PD have clinically significant impulsive behaviours (Weintraub et al., 2010), and recent estimates suggest that 1 in 5 people with PD will experience these behaviours at some point (Weintraub, 2019). However, the actual number of people with PD affected by increased impulsivity may be much higher, as these issues could be under-reported due to embarrassment and/or a person not recognising that they have problematic impulsive behaviours (Fasano, Pettorruso, Ricciardi, Conte, & Bentivoglio, 2010). Some of the commonly reported impulsive behaviours in PD include pathological gambling, compulsive buying, binge eating, and compulsive sexual behaviours (Djamshidian, Averbeck, Lees, & O'Sullivan, 2011). These behaviours can have a significant negative impact on the person with PD and their family and peers (Baumann-Vogel et al., 2015). For example, impulsive sexual behaviours can strain relationships with spouses and impulsive gambling behaviours can result in significant financial losses (Evans, Strafella, Weintraub, & Stacy, 2009; Santangelo, Barone, Trojano, & Vitale, 2013). Dopaminergic medications could also contribute to impulsivity issues in PD (Maréchal et al., 2015). Impulsive behaviours are also thought to be associated with cognitive (frontal) impairments observed in PD (Santangelo et al., 2009). Research suggests that frontal areas of the brain act to inhibit impulsive behaviours (Bickel et al., 2012). Impairment relating to these brain areas therefore reduces a person's ability to resist impulsive urges (Bickel et al., 2012; Santangelo et al., 2009). Chapter 2 will provide a comprehensive background on impulsivity in PD. Management of PD symptoms

1.7 Management of PD symptoms

For over 50 years, L-Dopa has been the main pharmacological treatment used for motor symptoms in PD (Schapira & Tan, 2012). Enzymes in the brain convert L-Dopa into dopamine, thereby providing the brain with an artificial source of dopamine (Schapira, Emre, Jenner, & Poewe, 2009). This alleviates motor symptoms of PD by compensating for the lack of dopamine in striatal areas of the basal ganglia (Ellis & Fell, 2017). Whilst L-Dopa is effective in reducing the severity of motor symptoms, some symptoms (postural instability, resting tremor) are less responsive to the medication (Brichta, Greengard, & Flajolet, 2013). It has been proposed that such treatment resistant symptoms require a higher dose of L-Dopa compared to other motor symptoms (Nonnekes et al., 2016). Over time the effectiveness of L-Dopa treatment tends to decline and is less able to reduce PD motor symptoms (Schapira et al., 2009). As PD progresses, striatal nerve terminals lose their capacity to store the dopamine provided by L-Dopa, meaning that a dose of L-Dopa becomes effective for shorter periods of time (Thanvi & Lo, 2004).

L-Dopa treatment has a range of adverse side-effects (Schapira et al., 2009). Motor complications of L-Dopa include dyskinesias (involuntary movements) and motor fluctuations (also referred to as the 'on-off' phenomenon; Schapira & Tan, 2012). Approximately 50% of people will experience motor complications of L-Dopa therapy five years after commencing treatment, which increases to 80% after ten years (Ellis & Fell, 2017; Thanvi & Lo, 2004). Higher doses of L-Dopa are associated with increased dyskinesia, which limits the amount of L-Dopa a person can tolerate (Jankovic & Aguilar, 2008). Dyskinesia symptoms can be debilitating and negatively affect a person's wellbeing (Schapira et al., 2009). The 'on-off' phenomenon refers to fluctuations in the severity of motor symptoms throughout the day (Jankovic & Aguilar, 2008). An 'on' period is when L-Dopa is working effectively and motor symptoms subside (Jankovic & Aguilar, 2008). An 'off' period is when the medication wears off and motor symptoms are no longer alleviated (Jankovic & Aguilar, 2008). Motor fluctuations have been attributed to the impaired capacity of dopaminergic neurons in the striatum to store dopamine (Jankovic & Aguilar, 2008). This means that the level of dopamine in the striatum is prone to variation, as the neurons cannot provide a buffer when the medication wears off before the next dose is taken (Schapira et al., 2009).

It is difficult to determine whether non-motor complications of L-Dopa are due to the progression of PD or due to fluctuating dopamine associated with the treatment (Aquino & Fox, 2015). Nevertheless, a number of non-motor issues are thought to be associated with L-Dopa, which are referred to as non-motor fluctuations, as they tend to fluctuate with the on-off states (Schapira & Tan, 2012). Although scarce research on the frequency of non-motor fluctuations is available, one study found that all of the examined participants (n = 50) reported experiencing at least one non-motor fluctuation over the previous few months (Witjas et al., 2002). Autonomic symptoms that fluctuate with medication include excessive sweating, bloating, urinary problems, and temperature regulation (Aquino & Fox, 2015). All of these autonomic symptoms are generally experienced during an off period (Aquino & Fox, 2015). Some behavioural non-motor fluctuations also occur during off periods including anxiety, depressed mood, and irritability (Beaulieu-Boire & Lang, 2015). Conversely, behavioural changes such as euphoria, hypomania, and hyperactivity can occur during on periods (Beaulieu-Boire & Lang, 2015). Hallucinations and psychotic symptoms are also associated with L-Dopa treatment (Schapira & Tan, 2012). More recently, impulsive behaviours have been linked to the use of L-Dopa (Beaulieu-Boire & Lang, 2015). It has been proposed that L-dopa might overdose parts of the dopaminergic system associated with reward processing with excess dopamine, which leads to increased impulsive behaviours (Maréchal et al., 2015).

Several adjunct drugs have been developed to increase the effectiveness of L-Dopa and minimise the complications associated with the drug (Jankovic & Aguilar, 2008). When motor complications develop, these adjunct drugs are administered in conjunction with L-Dopa as they help to maintain the effectiveness of L-Dopa whist minimising the dose required (Stowe et al., 2011). A class of drugs known as dopamine agonists act on dopamine receptors to amplify the effects of dopamine, and were initially used as an adjunct therapy to L-dopa (Ellis & Fell, 2017). However, dopamine agonists are now used to treat PD as a stand-alone drug to alleviate motor symptoms while delaying the initiation of L-Dopa therapy (Bonuccelli, Del Dotto, & Rascol, 2009). Delaying L-dopa therapy minimises the risk of experiencing adverse side-effects that can result from long-term L-Dopa use, making dopamine agonists particularly useful for the treatment of motor symptoms in those with early onset PD (Rana et al., 2016).

Monoamine oxidase B (MAO-B) and Catechol-O-methyl transferase (COMT) are two other classes of adjunct drugs used in PD (Ellis & Fell, 2017). Both of these enzymes reduce the rate at which dopamine is metabolised, thereby helping to maintain the level of dopamine in the striatum (Ellis & Fell, 2017). A meta-analysis by Stowe et al. (2011) reviewed the effectiveness of these adjunct drugs. The authors concluded that all of the drugs examined extended the on period of L-Dopa and reduced the amount of L-Dopa required to alleviate motor symptoms. Stowe et al. (2011) also stated that motor symptom severity is reduced by adjunct drugs. Although there are many benefits to using adjunct drugs alongside L-Dopa, they do increase the likelihood of a person experiencing dyskinesias and other adverse side effects, such as nausea, insomnia, hypotension, and hallucinations (Stowe et al., 2011). Dopamine agonists have also been implicated in the development of impulsivity issues in PD (Weintraub et al., 2010). The link between PD medications and impulsivity is explored in more detail in chapter 2.

Deep brain stimulation is another method used to alleviate motor symptoms in PD (Kalia & Lang, 2015). Deep brain stimulation is the surgical implantation of an electrode into the brain, which provides high frequency electrical stimulation to the subthalamic nucleus (Deuschl et al., 2006). This stimulation relieves motor symptoms and can be used when medications are no longer effective, typically in the advanced stages of PD (Deuschl et al., 2006). Some research has suggested that deep brain stimulation could increase susceptibility to impulsive behaviours in PD (Plessow, Fischer, Volkmann, & Schubert, 2014). However, the majority of studies investigating this relationship are limited by small sample sizes (Lim, Zuroswski, & Moro, 2010). Merola et al. (2017) recently conducted a large-scale study examining 172 PD participants pre and post deep brain stimulation. They reported that the rate of participants with clinically significant impulsive behaviours dropped from 17.3% before deep brain stimulation, to 12.7% four years after the procedure. The authors proposed that the observed reduction in impulsive behaviours is due to participants taking less dopamine agonists after the deep brain stimulation intervention.

Continuous dopamine delivery is a recently developed method, whereby dopaminergic drugs are delivered in a constant manner to minimise motor fluctuations (Schapira & Tan, 2012). This can be achieved using a medicated patch placed on the skin to administer dopamine, or by using a pump to deliver a dopamine gel straight into the small intestine (Wright & Waters, 2013). The continuous

delivery of dopaminergic medication helps to maintain a consistent level of dopamine in the striatum, avoiding the fluctuations in dopamine that can occur with oral medications (Schapira & Tan, 2012).

Cognitive behavioural therapy is a non-pharmacological intervention which has been suggested for the management of non-motor symptoms in PD. Dobkin et al. (2011) conducted a randomised control trial to examine whether cognitive behavioural therapy could reduce depression and anxiety in PD. The results demonstrated that cognitive behavioural therapy was effective in reducing self-reported depression and anxiety, with the greatest reductions being observed for depressive symptoms. Lakkhina Troeung, Egan, and Gasson (2014) conducted a similar randomised control trial. The results revealed that 6 months after a cognitive behavioural therapy intervention, 89% of participants showed clinically significant improvements in depression, and 56% demonstrated clinically significant improvements in anxiety. Despite research suggesting that cognitive behavioural therapy may be more effective in treating depression and anxiety than antidepressants (Lakkhina. Troeung, Egan, & Gasson, 2013), there is still scare research exploring the efficacy of cognitive behavioural therapy in PD (Egan, Laidlaw, & Starkstein, 2015).

Cognitive behavioural therapy has also been used to treat impulsivity issues in PD. Okai et al. (2013) conducted a randomised control trial to assess the use of cognitive behavioural therapy to treat impulsive behaviours in PD. The treatment group demonstrated significantly greater decreases in problematic impulsive behaviours compared to the control groups. Therefore, non-pharmacological interventions could be useful for treating impulsive behaviours in PD, however the research in this area is still very limited.

Repetitive transcranial magnetic stimulation is another non-pharmacological method that has been explored for use in PD (Chung & Mak, 2016). Repetitive transcranial magnetic stimulation is a non-invasive method that can be used to stimulate specific areas of the brain (Wagle Shukla & Vaillancourt, 2014). The technique uses an apparatus that generates a focal magnetic field, this magnetic field can painlessly penetrate the skull and stimulate the underlying brain tissue (Wagle Shukla & Vaillancourt, 2014). Two recent meta-analyses by Chung and Mak (2016) and Wagle Shukla et al. (2016) reviewed the literature to determine how effective repetitive transcranial magnetic stimulation is for improving PD motor symptoms.

Both the meta-analyses suggested that repetitive transcranial magnetic stimulation to the motor cortex improves motor functioning in PD over the long-term.

Whilst there is limited research available regarding the use of repetitive transcranial magnetic stimulation to manage depression in PD, some studies have demonstrated promising results (Seppi et al., 2011). Pal, Nagy, Aschermann, Balazs, and Kovacs (2010) conducted a double blind randomised control trial to investigate whether rTMS of the dorsolateral prefrontal cortex could improves depression in PD. The results revealed that 30 days after the intervention, the experimental group reported a 44% decrease in self-reported depression, whereas the control group did not report any significant change. N. Kovács et al. (2015) also conducted a double blind randomised control trial, but the stimulation was over the motor cortex. The results demonstrated that the control group had no significant changes 30 days after the intervention, whereas the experimental group reported a significant decrease in depressive symptoms.

The main focus of treatments has historically been to relieve the symptoms of PD (Kalia & Lang, 2015). However, research is now trying to halt or even reverse the progression of PD by developing medications which cease or slow α-synuclein from propagating through the brain, and break down Lewy inclusions (Kingwell, 2017).

1.8 Epidemiology

An issue with investigating epidemiology in PD is the accuracy of PD diagnoses, as false positives for PD make accurate estimates of PD prevalence difficult (Wirdefeldt, Adami, Cole, Trichopoulos, & Mandel, 2011). Hughes et al. (1992) examined the brains of 100 deceased patients who had a PD diagnosis during their lifetime. They found that only 76% of the deceased patients met the criteria for PD based upon their neuropathology. Recent advancements in PD diagnostic criteria (such as the United Kingdom Brain Bank Criteria) have improved the precision of diagnoses, but accuracy remains around 83% (Rizzo et al., 2016).

The method of sampling in epidemiological studies also needs to be considered. Studies which rely upon medical records risk excluding people who have not yet been diagnosed, or who have been misdiagnosed (Pringsheim, Jette, Frolkis, & Steeves, 2014). Such research depends on these records being comprehensive and

complete (Wirdefeldt et al., 2011). Two large reviews of PD epidemiology conducted by Pringsheim et al. (2014) and Wirdefeldt et al. (2011), argue that door-to-door sampling is the most accurate sampling method. This involves sampling a section of the population for cardinal PD symptoms (tremor, bradykinesia, etc.), and confirming suspected cases with a standardised clinical assessment. Door to door sampling methods generally yield higher prevalence estimates than alternative methods (Wirdefeldt et al., 2011). Pringsheim et al. (2014) reviewed 47 studies which employed a door-to-door sampling methodology across a range of geographic locations. The results revealed that the prevalence of PD increases with age. The aggregated prevalence rates were as follows: 41 cases per 100,000 people (40 to 49 years old) 107 per 100,000 (50 to 59) 173 per 100,000 (55 to 64) 428 per 100,000 (60 to 69) 425 per 100,000 (65 to 74) 1,087 per 100,000 (70 to 79), and 1,903 per 100,000 (80+). Cases of PD prior to the age of 40 are very rare (Wirdefeldt et al., 2011). These rates could be a slight underestimate, as the rates obtained from the more comprehensive studies were higher than those rated as being of a lessor quality. As a rough estimate, these findings place the lifetime risk of developing PD in the region of 2% (Elbaz et al., 2002). The largest study conducted to date estimates that around 13% of people with PD have significant issues with impulsive behaviours (Weintraub et al., 2010).

1.8.1 Gender

Men are at an increased risk of developing PD, with a reported male to female ratio of 1.49 (Picillo et al., 2017). A recent meta-analysis indicated that before the age of 50, the male to female ratio is approximately 1.3. However, after the age of 75 this ratio increases to over 1.5 (Moisan et al., 2015). A few factors may contribute to this gender disparity. Males have increased occupational exposure to toxins such as pesticides and are typically at a higher risk of head trauma over the lifespan (both of which are risk factors for PD; Elbaz et al., 2009; Gillies, Pienaar, Vohra, & Qamhawi, 2014). Female sex hormones may also protect against PD through a number of mechanisms (K. M. Smith & Dahodwala, 2014). These include reducing oxidative stress in the brain, preventing the formation of damaging Lewy bodies, and decreasing the metabolism of dopamine (K. M. Smith & Dahodwala, 2014). Furthermore, structural differences in the nigrostriatal dopaminergic pathway

in females may further reduce the risk of PD (Gillies et al., 2014). Men are also at a greater risk demonstrating heightened impulsivity in PD (Gatto & Aldinio, 2019).

1.8.2 Ethnicity

In terms of prevalence with respect to ethnicity, there is limited data on which to base any meaningful conclusions (Pringsheim et al., 2014). Pringsheim et al. (2014) reported a significantly lower prevalence of PD in Asian populations in the 70-79 age bracket (646 per 100,000) compared to prevalence rates in Europe, North America, and Australia (1,602 per 100,000). Van Den Eeden et al. (2003) specifically examined differences in PD prevalence by ethnicity (African-American, Asian, Hispanic, and Caucasian). Their findings indicated no significant differences between the groups, but the rates among the African-American and Asian groups trended toward being significantly lower than the other ethnic groups. Overall, the limited research and multiple methodologies employed within this field make it difficult to determine whether any true differences exist between different ethnic groups in terms of PD prevalence (Ascherio & Schwarzschild, 2016).

1.9 Risk factors

Some genetic profiles have been associated with the development of PD (Mullin & Schapira, 2015). Six chromosomal regions have been strongly linked to PD, a single mutation in one of these regions can cause monogentic PD which accounts for approximately 5% of PD cases (Klein & Westenberger, 2012). A number of different chromosomal regions have also been implicated in PD, and there is growing evidence that multiple mutations across these regions interact to cause a polygenetic form of PD (Mullin & Schapira, 2015). Polygenetic PD is thought to account for 3-5% of PD cases (Escott-Price et al., 2015). Currently, approximately 10 % of PD cases can be attributed to genetic factors, the remaining cases are classified as idiopathic (i.e., there is no known cause; Ascherio & Schwarzschild, 2016). Genetic factors are also though to increase the risk of developing impulsivity issues for people with PD, however this link is less established (Gatto & Aldinio, 2019). A number of non-genetic risk factors have also been identified as contributing to PD (Bellou, Belbasis, Tzoulaki, Evangelou, & Ioannidis, 2016).

Bellou et al. (2016) conducted an 'umbrella' review, which compiled 75 systematic reviews and meta-analyses examining risk factors in PD. The authors ranked the risk factors identified in the literature based upon how strongly each factor was associated with PD. Class I (being the strongest predictor) required >1000 cases, a p value < 10^{-6}, no evidence of small study effects, and limited heterogeneity. Class II had the same criteria, but tolerated more heterogeneity and small study effects. The results indicated that a history of constipation was the only risk factor that met the Class I requirement. As discussed, research suggests that neurodegeneration in the enteric nervous system causes the constipation observed in PD (Cersosimo & Benarroch, 2012). Such findings are said to support Braak's PD staging hypothesis (Klingelhoefer & Reichmann, 2015)

Although only constipation met the class I criteria set by Bellou et al. (2016), a number of other risk factors for PD have been identified. Ascherio and Schwarzschild (2016) conducted a meta-analysis on prospective cohort studies to identify risk factors in PD. Prospective cohort studies involve collecting extensive information about participants and following them over a long period of time. They have an advantage over other methodologies as they do not depend on a participant's retrospective recollection of their lifestyle, and are therefore less subjective. Ascherio and Schwarzschild (2016) identified that the consumption of dairy products, exposure to pesticides, a history of melanoma, and traumatic brain injury were all risk factors for PD. A number of other factors indicated a possible relationship with PD, but the associations are less definitive. It is important to note that as the nature of these studies is correlational, they can only reveal factors that are related to PD and cannot be used to imply causality.

1.10 Protective factors.

Bellou et al. (2016) also examined possible protective factors in their umbrella review, ranking them based upon the strength of their association with PD. They reported that physical activity was a protective factor that met their criteria for a class I association. Physical activity increases a protein called brain-derived neurotrophic factor, which helps to encourage the growth of new neurons and protect existing neurons against insults related to the pathogenesis of PD (Mattson, 2014). Exercise may also increase plasma urate (Q. Xu et al., 2010). Urate is an antioxidant

that is produced when purines are metabolised in the body (during exercise), and is thought to reduce the risk of PD (Wen et al., 2017). It has been proposed the link between reduced physical activity and an increased risk of PD is that people with PD are less likely to exercise (as a result of the disease) before symptom onset (Bellou et al., 2016). However, contrary to this explanation, a recent longitudinal study demonstrated that exercise in early adulthood was associated with a reduced risk of PD, whereas more recent physical activity was not (Tanner & Comella, 2015).

The consumption of nicotine (i.e., smoking) protects against PD, Ascherio and Schwarzschild (2016) noted that despite numerous attempts to rule out confounding factors, this association remains. Animal models have suggested that nicotine can protect against damage to dopaminergic neurons in nigrostriatal pathways (Quik, O'Neill, & Perez, 2007). Nicotine may elicit the release of dopamine, or increase intercellular calcium levels in the brain, which is thought to help maintain the integrity of nigrostriatal pathways (Quik, O'Neill, & Perez, 2007).

Caffeine consumption also reduces the risk of PD (Ascherio & Schwarzschild, 2016). Several longitudinal studies suggest that higher consumption of caffeinated products (such as coffee and tea) is associated with lower incidences of PD (Wirdefeldt et al., 2011). Similar to nicotine, caffeine is thought to have some neuroprotective properties (Chen et al., 2001). It has been hypothesised that changes in personality prior to symptom onset may make those with PD less likely to seek out stimulants such as nicotine and caffeine (Evans, Lawrence, et al., 2006). A more recent explanation suggests that smoking and caffeine may cause changes in the microbiome (bacteria) of the gut, which in turn could reduce the risk of PD by promoting anti-inflammatory bacteria (Derkinderen, Shannon, & Brundin, 2014).

Chapter 2 Impulsivity

Impulsivity has historically been a difficult construct to define, and there is still limited consensus as to how impulsivity should be conceptualised (Sharma et al., 2014). Despite these difficulties, an understanding of the construct of impulsivity is important for both clinical and research purposes (Enticott & Ogloff, 2006). In its general sense, impulsivity is the tendency to act without considering the potential consequences of a behaviour (Carver, 2005). Several different concepts such as sensation seeking, risk taking, boredom susceptibility, failure to plan, and venturesomeness have all been used to describe impulsivity (G. T. Smith et al., 2007). These varying conceptualisations of impulsivity are often underpinned by different theoretical approaches (Cross, Copping, & Campbell, 2011) A lack of clarity can make it difficult to determine which means of operationalising impulsivity is the most appropriate, which is evident in the PD literature where several different measures of impulsivity with different theoretical underpinnings are commonly used (Mestre et al., 2013). Therefore, before discussing impulsivity in Parkinson's, this thesis will consider some of the most prominent definitions of impulsivity.

2.1 Models of impulsivity

2.1.1 Personality based models of impulsivity

A considerable amount of research has focused on impulsivity as a personality trait (Carver, 2005). In one of the earliest considerations of impulsivity as an aspect of personality, H. J. Eysenck and Eysenck (1968) developed the measure 'Eysenck's Personality Inventory' based upon their two factor model of personality. This model proposed that personality encompasses two broad factors - neuroticism and extraversion. In this model, impulsivity was thought to be an aspect of extraversion (Whiteside & Lynam, 2001). S. B. G. Eysenck and Eysenck (1978) later expanded their model of personality to three factors with the addition of a 'psychoticism' factor. In the three factor model, impulsivity was specifically related to high levels of neuroticism, extraversion, and psychoticism (S. B. G. Eysenck & Eysenck, 1978).

Another personality trait measure of impulsivity is the 'Sensation Seeking Scale' by Zuckerman (1971). Sensation seeking refers to individual differences in the

need for stimulation, and consists of four separate factors, thrill and adventure seeking, experience seeking, disinhibition, and boredom susceptibility (Zuckerman, 1971). Individuals with high sensation seeking tendencies as measured by the Sensation Seeking Scale are prone to impulsive behaviours, such as substance abuse, risky driving, and antisocial behaviour (Carver, 2005; Fernández-Artamendi, Martínez-Loredo, Fernández-Hermida, & Carballo-Crespo, 2016).

Whiteside and Lynam (2001) stated that no personality based conceptualisation of impulsivity had yet received widespread acceptance. To address this, they examined impulsivity using an established personality measure (the revised NEO Personality Inventory). The NEO Personality Inventory assesses personality based upon the big five personality traits. Whiteside and Lynam (2001) administered the NEO Personality Inventory alongside several existing measures of impulsivity to 437 young adults and performed a factor analysis on the data. The results produced four factors: urgency, lack of premeditation, lack of perseverance, and sensation seeking. The authors concluded that these four factors are distinct personality traits that are often incorrectly bundled together and labelled as impulsivity. In their view, impulsivity is a construct that encompasses these separate but related factors.

One of the most commonly used measures of impulsivity is the Barratt Impulsiveness Scale (Stanford et al., 2009). The current version of the measure was developed by Patton, Stanford, and Barratt (1995) after several revisions of the original measure. Barratt (1959) initially developed the scale to distinguish impulsiveness from anxiety. As the measure was refined, Barratt concluded that impulsivity was not unidimensional, and that the concept of impulsivity should go beyond a personality trait focussed approach (Patton et al., 1995; Stanford et al., 2009). To more comprehensively describe and measure impulsivity, Patton et al. (1995) drew information from medical, psychological, behavioural, and social models. Their work examined existing self-report measures of impulsivity, behavioural tasks of impulsivity, and animal-based research (Barratt, 1993). Patton et al. (1995) then developed a range of items to capture the various aspects of impulsivity that they had identified. The most recent version of the Barratt Impulsiveness Scale identifies three main factors that comprise impulsivity; motor impulsiveness, attentional impulsiveness, and non-planning impulsiveness (Patton et al., 1995). It should be noted that subsequent research has sometimes failed to replicate this three factor structure. Reise, Moore, Sabb, Brown, and London (2013)

performed a confirmatory factor analysis on the Barratt Impulsiveness Scale, and the results did not support the three factor model proposed by Patton et al. (1995), which casts doubt on the validity of partitioning impulsivity into three constructs.

The conceptualisation of impulsivity in terms of personality has been challenging and there is no true consensus in the literature (Sharma et al., 2014). In their meta-analysis, Cross et al. (2011) reviewed numerous widely used theoretical models and measures of impulsivity, and concluded that a commonality across these different views of impulsivity is that it involves an over-attraction to reward and under-sensitivity to punishment. Whilst this definition may appear overly simplistic, in the interest of scientific parsimony it is helpful think of impulsivity in this manner.

2.1.2 Biology based model of impulsivity

J. A. Gray (1987) proposed a biological basis for behaviour named the biopsychological theory of personality. The model is based on the premise that human behaviour is influenced by fundamental biological mechanisms. J. A. Gray (1987) derived his theory from his research into animal and human physiology, and suggested that behaviour is governed by two main systems, the first of which is the behavioural activation system (BAS). This system is sensitive to cues of reward and motivates behaviours to pursue reward. Gray proposed that dopaminergic pathways are the primary physiological basis to the BAS, these pathways are thought to respond to rewarding cues in the environment to motivate an organism to engage in approach behaviours (Carver & White, 1994). The second system is the behavioural inhibition system (BIS) and, in contrast to the BAS, it responds to cues of punishment. The BIS acts to moderate behaviour to avoid punishment. According to Gray, the BIS involves the cholinergic septohippocampal system and projections from this system to the frontal lobe (Carver & White, 1994). In their review, Cross et al. (2011) acknowledged that Gray's (1987) theory fits with their interpretation of impulsive behaviour - that impulsivity is the result of over-attraction to reward and under-sensitivity to punishment. Based on Gray's (1987) biopsychological theory of personality, Carver and White (1994) developed the BIS/BAS scale. The BIS/BAS scale is a self-report measure that operationalises the behavioural activation and inhibition systems proposed by Gray (1987). Since its development, the BIS/BAS scale has become the most widely used measure of the behavioural activation and inhibition systems.

2.1.3 Summary of impulsivity models

The aforementioned theories represent the most pertinent models of impulsivity that exist in the literature. These varying models demonstrate the multifaceted nature of impulsivity, and the difficulty that exists in conceptualising impulsivity. Researchers have used a number of different approaches to clarify the nature of impulsivity, but despite this a unifying theory of impulsivity remains an enigma. Correspondingly, a multitude of different measures are used in the impulsivity literature which impedes research, as it can be difficult to draw comparisons between studies that use different assessment instruments (Sharma et al., 2014). Furthermore, this issue frequently leads to concerns that impulsivity research suffers from the 'jingle fallacy', whereby different constructs are incorrectly referred to as being the same construct (i.e., impulsivity; Enticott & Ogloff, 2006; Sharma et al., 2014. Nonetheless, it is important to examine impulsivity as it associated with a number of negative outcomes, including poor social functioning, risky behaviours, criminality, and impaired mental health (Sharma et al., 2014). Impulsivity is considered to be a feature which underlies difficulties experienced by numerous clinical populations such as people with schizophrenia (Enticott & Ogloff, 2006; Sharma, Kohl, Morgan, & Clark, 2013).

2.2 Populations with impulsivity issues

A number of different clinical populations have been identified as having problematic impulsive behaviours (Enticott & Ogloff, 2006). Reviewing these populations helps to identify whether any communalities exist between them and PD. An Impulse Control Disorder (ICD) is a clinical diagnosis given to a person when their impulsive behaviours significantly impact on the their own wellbeing and/or the wellbeing of others (Black, 2014). The DSM-5 includes a chapter named 'Disruptive, Impulse-Control and Conduct Disorders', which describes conditions characterised by issues with impulse control (American Psychiatric Association, 2013). The chapter describes several disorders that are characterised by impulsiveness including, kleptomania, pyromania, conduct disorder, and intermittent explosive disorder (American Psychiatric Association, 2013). If a person has significant problematic impulsive behaviours, but they do not meet the criteria for a specific disorder, it is referred to as an 'unspecified disruptive impulse control and conduct disorder'

(American Psychiatric Association, 2013). While the disorders included in the DSM-5 are characterised by issues with controlling impulsive behaviours, several separate clinical populations also demonstrate increased impulsivity.

2.2.1 Attention Deficit and Hyperactivity Disorder

Impulsivity is a core symptom of Attention Deficit Hyperactivity Disorder (ADHD), and is thought to be one of the primary factors underlying the problematic behaviours observed in ADHD (Shirley & Sirocco, 2014). ADHD in children is associated with reduced social functioning, emotional difficulties, and impaired academic achievement (Nigg, 2013; Ros & Graziano, 2017). The impulsive aspect of ADHD in children often persists into adulthood, contributing to a range of problematic outcomes including violence, risky sexual behaviours, and poor occupational performance (Wilbertz et al., 2012). Deficits in executive functions are another key characteristic of ADHD (Luman, Tripp, & Scheres, 2010; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). Barkley (1997) proposed that ADHD is the direct result of impaired executive functions, a theory which has gained widespread acceptance in the literature. Executive functions are a range of higher order processes that enable a person to engage in purposeful goal-directed behaviour (Gilbert & Burgess, 2008). Executive functions are primarily reliant on prefrontal areas of the brain (Antshel, Hier, & Barkley, 2014). In line with this, a meta-analysis of functional imaging research concluded that people with ADHD consistently demonstrate reduced activation of frontal areas when completing executive functioning tasks (Cortese et al., 2012). It has been suggested that that the frontal deficits and corresponding impaired executive functioning observed in ADHD, contribute to the increased presence of impulsive behaviours in the population (Carmona et al., 2009)

2.2.2 Substance use disorder

A diagnosis of substance use disorder is given to a person who continually uses or has dependence on drug(s), despite this use having a detrimental impact on their wellbeing (Verdejo-García, Lawrence, & Clark, 2008). Impulsivity has been identified a risk factor for developing a substance use disorder (de Wit, 2009), as impulsive individuals are more likely to experiment with drugs (Grant & Chamberlain, 2014). A longitudinal study by Kirisci, Tarter, Mezzich, and Vanyukov

(2007) found that self-reported impulsivity between the ages of 10-12 predicted the likelihood of having a substance use disorder at 22, supporting the notion that impulsivity is a risk-factor for substance abuse. People with a current substance use disorder also demonstrate heightened impulsivity, which is thought to contribute to the maintenance of their addiction (Grant & Chamberlain, 2014). Dysfunction of prefrontal areas, particularly the orbital frontal cortex, is associated with impulsive choices in people with a substance use disorder (Crews & Boettiger, 2009). Boettiger et al. (2007) conducted an imaging study which compared a group of participants with a history of alcohol abuse to matched controls (matched for age, socioeconomic status, education, and IQ). Participants performed a decision-making task assessing whether they would favour small immediate rewards over larger delayed rewards (a common assessment of impulsivity). The results revealed that the alcohol abuse group behaved more impulsively on the task, and that this behaviour correlated with less neural activation in the orbital frontal cortex (part of the prefrontal cortex). It is thought that the impaired frontal functioning associated with substance use disorders makes people more liable to impulsive choices, and therefore more likely to experiment with drugs (Crews & Boettiger, 2009). Continued drug use damages frontal areas of the brain which impairs judgement and increases impulsive tendencies. This creates a feedback loop that makes substance users more likely to continue problematic drug use over time.

2.2.3 Schizophrenia

Impulsivity is considered to be a core feature of schizophrenia (Ouzir, 2013) and has been linked to an increased risk of substance use, aggression, and suicide risk in people with schizophrenia (Hoptman, 2015; Iancu et al., 2010; Ouzir, 2013). Kester et al. (2006) examined how young people with schizophrenia performed on a laboratory based measure of impulsivity compared to healthy match controls (matched for age, gender, ethnicity, and socioeconomic status). The laboratory task used was the Iowa Gambling Task, a common impulsivity task which measures decision making in response to reward and punishment. The results indicated that the group with schizophrenia performed more impulsively on the task and did not adjust their behaviour in response to punishment/loss. These findings are in line with other studies reporting higher impulsiveness in people with schizophrenia (Kaladjian, Jeanningros, Azorin, Anton, & Mazzola-Pomietto, 2011).

Impaired executive functioning is also considered to be a key characteristic of schizophrenia (Liu et al., 2011). A meta-analysis of 113 studies by Fioravanti, Carlone, Vitale, Cinti, and Clare (2005) confirmed that people with schizophrenia consistently perform worse on measures of executive functioning compared to healthy controls. The authors noted that people with schizophrenia did not outperform controls in any of the 113 studies reviewed. It has been suggested that deficits in executive function may impair the ability of people with schizophrenia to have insight in to their illness and may make them more likely to engage in impulsive behaviours (Lysaker, Bryson, Lancaster, Evans, & Bell, 2003). Reduced executive functioning in schizophrenia has been linked to functional abnormalities in frontal areas of the brain (Eisenberg & Berman, 2009). Minzenberg, Laird, Thelen, Carter, and Glahn (2009) performed a meta-analysis of imaging research investigating the neural correlates of reduced executive function performance in schizophrenia. The results revealed that the under-recruitment of frontal areas (especially the dorsolateral prefrontal cortex) was associated with impaired executive functioning in people with schizophrenia. The impaired functioning of frontal areas observed in schizophrenia is also thought to contribute to impulsive behaviours (Ouzir, 2013). In their review of impulsivity in schizophrenia, Ouzir (2013) noted that impulsive behaviours were associated with both reduced brain volume in prefrontal areas and decreased activation of prefrontal areas.

2.2.4 Frontotemporal dementia

Frontotemporal dementia refers to a group of neurodegenerative diseases which are characterised by atrophy in frontal and temporal areas of the brain (Bang, Spina, & Miller, 2015). One of the main symptoms of frontotemporal dementia is impulsivity, which typically manifests as a range of inappropriate behaviours (Pressman & Miller, 2014). People with frontotemporal dementia are known to make inappropriate remarks, display heightened aggression, overeat, and engage in pathological gambling (Bang et al., 2015; Manes et al., 2010). Executive functioning deficits are also characteristic of the disorder, and are thought to result from the degeneration of prefrontal areas (Kurz, Kurz, Ellis, & Lautenschlager, 2014). Peters et al. (2006) examined whether impulsivity in frontotemporal dementia correlated with impaired frontal functioning using Positron Emission Topography (PET) imaging. The results demonstrated that compared to age matched controls, the

participants with frontotemporal dementia had decreased activation in prefrontal areas. Furthermore, the under-recruitment of prefrontal areas was associated with increased impulsive behaviour on a disinhibition task.

2.3 Executive functioning, frontal abnormalities, and impulsivity

Some commonalities exist across these impulsive clinical populations. Executive dysfunction appears to be common in disorders that demonstrate problematic impulsive behaviours. Correspondingly, these populations also demonstrate abnormalities in frontal brain regions. There is an apparent link between frontal abnormalities, impaired executive functioning, and increased impulsivity in all of the populations discussed. Executive abilities are often impaired in people with PD (Santangelo, Raimo, & Barone, 2017). Therefore, exploring this apparent link between reduced executive functioning and impulsivity issues has the potential to provide crucial insights into why some people with PD experience heightened impulsivity. Bickel et al. (2012) proposed that impulsivity and executive functioning might be antipodes that exist on opposite ends of a shared spectrum. To support their hypothesis, Bickel et al. (2012) point to the shared neural substrates of both executive functions and impulsivity outlined in the Competing Neurobehavioural Decision Systems Theory.

2.4 Competing Neurobehavioural Decision Systems Theory

Bechara (2005) developed a neural framework to explain the heightened impulsivity observed in people with substance addictions, which has subsequently been referred to as the Competing Neurobehavioural Decision Systems Theory (Bickel et al., 2012). Bechara (2005) noted that people with addictions struggle to make choices based upon long-term consequences, and are unaware that their decision making is impaired. Both of these outcomes are characteristic of people with damage to frontal areas of the brain. This led Bechara (2005) to propose that impulsive decisions arise from an interaction between two separate systems, an impulsive system and a reflective system. When there is an imbalance between these two systems, effective decision making is compromised.

The interaction of these two systems depends largely on their ability to trigger affective states in response to stimuli. The theory follows that numerous affective states can be triggered at the same time in response to a stimulus, resulting in an overall positive or negative state. If the overall affective state triggered by a stimulus is positive, then the person will find it rewarding and pursue that stimulus. Whereas if the overall state is negative, the person will avoid pursing that stimulus. Based upon several imaging studies, Bechara (2005) proposed that the reflective system is largely dependent on prefrontal areas. Bechara (2005) cited research which demonstrates that people with substance addictions have structural abnormalities in prefrontal areas, including the dorsolateral prefrontal cortex, the ventromedial prefrontal cortex, and the anterior cingulate cortex (Franklin et al., 2002; Matochik, London, Eldreth, Cadet, & Bolla, 2003). The reflective system triggers affective states based on the long-term consequences of a behaviour. The triggered affective states can be based upon previous experiences associated with that stimulus. In the context of drug use this could be social, financial, and legal issues caused by previous drug consumption. Affective states can also be triggered by what a person has leant about a behaviour, for example they may have been taught that drug use is harmful, or that it is against the law. This means that a person does not have to experience the consequences of a behaviour first hand to avoid engaging in a potentially dangerous behaviour. If the long-term outcomes of a behaviour are negative, the reflective system will trigger negative affective states to avoid the behaviour and its associated consequences. By triggering these emotional responses, the reflective system serves to exert top-down control over the impulsive system, and supresses impulsive urges that may have negative consequences if acted upon.

The impulsive system proposed by Bechara (2005) is comprised of limbic areas, specifically the amygdala. This system seeks out immediate rewards in the environment. The amygdala responds to reward related cues in the environment to initiate approach behaviours. A rewarding stimulus triggers automatic and immediate affective responses from the amygdala, which drives the pursual of that stimulus. Rewarding stimuli can be innately rewarding (e.g., food) or can be learnt over time to evoke these responses (e.g., money). The impulsive system uses bottom-up processes to induce positive affective states and consequently motivate behaviour. Bechara (2005) explains that the main mechanism behind the impulsive systems bottom up influence is the amygdala's ability to trigger changes in midbrain neurotransmitters,

such as dopamine and serotonin. These neurotransmitters can modulate cerebral activity and enable the impulsive system to exert a bottom-up influence on impulsive behaviour. The impulsive system and the reflective system interact and compete with each other to influence decision making. If a person has a hyperactive impulsive system or a weak reflective system, they may be more inclined towards impulsive decisions/behaviours. Like executive areas of the brain, the functioning of limbic areas is also affected by PD (Averbeck et al., 2014). As such, it is worthwhile investigating the merit of the Competing Neurobehavioural Decision Systems Theory, as the theory suggests that impaired executive and limbic functioning in PD could contribute to impulsivity issues.

2.4.1 Supporting evidence

Addiction literature has linked impulsive behaviours to limbic 'reward circuity' (Pierce & Kumaresan, 2006). Dopamine released in limbic areas reinforces rewarding behaviours, and it is this dopamine release which seems to drive increased impulsive drug taking in substance abusers (Pierce & Kumaresan, 2006; Ramaekers et al., 2016). The link between increased dopamine in limbic areas and impulsivity has also been demonstrated in people with impulsive tendencies. Joshua et al. (2010) used PET imaging to observe dopamine released in the mesolimbic reward system following a small amphetamine dose (used to induce the release of dopamine). Participants self-reported their psychopathic traits on a commonly used measure, which includes a section that assesses 'impulsive antisociality'. The results revealed that impulsive antisociality was positively associated with greater dopamine release in the reward system. The same amphetamine dose resulted in a greater release of dopamine for the impulsive individuals compared to those who self-reported as being less impulsive. Joshua et al. (2010) concluded that those with impulsive psychopathic traits demonstrated a hypersensitive limbic reward system.

The relationship between impulsivity and dopamine in limbic areas has also been demonstrated in a population of people with schizophrenia (Richter et al., 2015). Richter et al. (2015) used fMRI imaging to observe the neural correlates of reward processing in people with schizophrenia, compared to controls matched for age, gender, and education. The participants took part in a decision making assessment which required them to forgo short term immediate rewards to successfully complete the long term goal of the task. The participants with

schizophrenia performed significantly worse on the task, they tended to be impulsive and choose the immediate rewards rather than the stimuli that would achieve the long term goals of the task. Compared to controls, the participants with schizophrenia also demonstrated increased activation in the ventral striatum (an area which responds to cues of reward) when the immediate reward was presented. The increased activation of the ventral striatum was thought to be the result of increased dopamine release in the mesolimbic reward system, representing a 'hyperactive reward system'. Furthermore, the people with schizophrenia displayed abnormal activation of frontal areas when deciding between the stimuli. Richter et al. (2015) concluded that the frontal areas were impaired, and therefore were less able to provide top-down control over the mesolimbic reward system. Therefore, the participants with schizophrenia demonstrated hyperactive limbic responses coupled with impaired frontal recruitment, which was associated with impulsive decision making.

The findings of these studies are congruent with the idea that the limbic system drives impulsive behaviours. The results of the Richter et al. (2015) study also suggest that frontal areas play a role in regulating impulsive behaviours. These results are consistent with other studies which have examined the relationship between frontal functioning and impulsivity. Decreased cortical thickness in frontal areas has been linked to impulsive tendencies in the general population and a range clinical populations (Holmes, Hollinshead, Roffman, Smoller, & Buckner, 2016; Richter et al., 2015), suggesting frontal areas provide top-down inhibitory control of impulsive areas. Despite the knowledge that these areas are important for reward processing and impulsivity, it is only recently that the causal role of these brain regions in reward seeking behaviour is being revealed (Ferenczi et al., 2016).

A study by Ferenczi et al. (2016) has provided comprehensive insight into the neurological basis of reward seeking behaviours. The study employed the use of optogenetically modified rats, which allowed the researchers to directly stimulate or inhibit a target area of the brain. Genetically engineered viruses were implanted into the rat's brain. When these viruses expressed themselves, the infected neurons were excited or inhibited using specific wavelengths of light delivered via a fibre optic cable implanted into the rat's brain. In their first experiment, Ferenczi et al. (2016) excited midbrain dopaminergic neurons to examine any impact on reward seeking behaviour, by delivering specific wavelengths of light to the substantia nigra and ventral tegmental area. The rat was given a choice between two levers, a neutral one,

and one that would stimulate the midbrain dopaminergic neurons. The results indicated a significant preference for the stimulus lever over the neutral lever. Furthermore, the stimulation of mid brain dopamine neurons increased blood oxygen levels in the unstimulated ventral striatum. The authors concluded that exciting the midbrain dopamine neurons increased synaptic input into the ventral striatum, which in turn increased reward seeking behaviour in the rat. The authors then inhibited the same dopaminergic neurons in the midbrain using wavelengths of light that 'silence' these neurons. The rat was free to roam between two chambers, in one chamber the dopaminergic neurons would be inhibited and in the other no stimulation would occur. The rat spent significantly less time in the inhibition chamber. These results suggest that the rats found the stimulation of midbrain dopaminergic neurons and the corresponding release of dopamine rewarding, whereas the inhibition of the same neurons had the opposite effect.

In their next experiment, Ferenczi et al. (2016) explored whether activity in the medial prefrontal cortex would moderate reward seeking behaviour. They wanted to examine whether stimulating the medial prefrontal cortex would decrease reward seeking behaviour, which would indicate that these areas exert top-down control over reward seeking behaviours. The authors used a slightly different technique in which the fibre optic light was used to increase the excitability of the stimulated region over a longer time span. When the medial prefrontal cortex was stimulated, the rats showed a reduced preference for sucrose water (innately rewarding for rats) compared to plain water. This reduced preference was only observed on days when the medial prefrontal cortex was stimulated. In contrast, a control group of rats maintained their preference for sucrose water over the same period. This indicates that prefrontal areas play a role in exerting top-down control over reward seeking behaviour, as the activation of prefrontal areas reduced reward seeking behaviour.

To further explore the relationship between prefrontal areas and midbrain dopaminergic neurons, Ferenczi et al. (2016) examined how stimulating these areas affected blood oxygen flow to the ventral striatum. When the midbrain dopaminergic stimulation was present, blood oxygen flow to the ventral striatum increased. These changes in blood oxygen are thought to be reflect an increased release of dopamine in the ventral striatum. However, Ferenczi et al. (2016) then demonstrated that this increased striatal response to midbrain dopaminergic stimulation was significantly reduced when the prefrontal cortex was stimulated in the rats. Furthermore, these

changes in the activation of the ventral striatum resulted in behavioural changes in the rats. The rats again had access to a neutral chamber and a stimulation chamber which, upon entry, would start midbrain stimulation (that the rats found rewarding in the first experiment). During the first 10 minutes of free roaming, the rats preferred the stimulation chamber. However, when the prefrontal cortex was activated for the next 10 minutes, this preference disappeared. The prefrontal cortex stimulation was then switched off for the last 10 minutes of the experiment, and the preference for the midbrain stimulation chamber returned. This experiment demonstrates that midbrain neurons exert bottom-up influence and drive reward seeking behaviour by increasing activation in the ventral striatum. In contrast, the stimulation of prefrontal areas supressed activation in the ventral striatum and reduced reward seeking behaviour, demonstrating that prefrontal areas exert top-down control to reduce reward seeking behaviour.

The results of Ferenczi et al. (2016) are in line with the Competing Neurobehavioural Decision Systems Theory and are consistent with previous research into reward processing. Wang, Smith, and Delgado (2016) reviewed functional magnetic resonance imaging studies that have investigated reward processing in humans. They found that the presentation of rewarding stimuli is consistently associated with increased activation in the ventral striatum.

2.5 The role of the ventral striatum

The ventral striatum is the point of intersection between mesolimbic dopaminergic neurons originating in the midbrain (substantia nigra and ventral tegmental area), and cortical projections originating from frontal areas (Suzanne & Brian, 2009). Essentially, the ventral striatum is positioned to drive and inhibit reward seeking behaviour (Haber, 2011). The release of dopamine in the ventral striatum is thought to play a key role in the motivation and reinforcement of behaviours (Daniel & Pollmann, 2014). Dopamine motivates the pursual of reward by triggering a feeling of 'wanting' in response to rewarding stimuli (Berridge, Robinson, & Aldridge, 2009). Midbrain dopaminergic neurons drive bottom up processes to initiate reward seeking behaviour via mesolimbic projections to the ventral striatum (Haber, 2011). When a rewarding cue is presented to a person, midbrain dopaminergic neurons fire and increase activation in the ventral striatum

though these mesolimbic dopaminergic projections (Daniel & Pollmann, 2014). It is the ability of the midbrain neurons to increase phasic dopamine release in response to rewarding cues that motivates reward seeking behaviour (Schultz, 2007). Conversely, frontal areas apply a top down influence to moderate and supress reward seeking behaviour. It is thought that frontal areas increase tonic dopamine release in the ventral striatum, which reduces the ability of the midbrain dopaminergic neurons to cause dopamine fluctuations in the striatum in response to reward (Ferenczi et al., 2016). Frontal areas of the brain also have the largest afferent inputs into the ventral striatum (Haber, 2011). These glutamatergic projections also allow frontal areas to modulate neural activity in the ventral striatum, further allowing them to moderate reward seeking behaviours (Diekhof & Gruber, 2010; Ferenczi et al., 2016; Gleich et al., 2015).

The release of dopamine in the ventral striatum has been linked to problematic impulsive behaviours in PD (Averbeck, O'Sullivan, & Djamshidian, 2014; O'Sullivan et al., 2011). O'Sullivan et al. (2011) presented various rewarding cues to a group of PD participants diagnosed with Impulse Control Disorders (ICDs), and a group of PD participants without ICDs (matched for age and gender). Using PET scans, they observed changes in the level of dopamine released in the ventral striatum when rewarding cues were presented to participants, such as pictures of food and money. The results demonstrated that the PD ICD group released significantly more dopamine into the ventral striatum in response to the rewarding cues, compared to the non-ICD group. The authors concluded that people with an ICD in PD are sensitised to rewarding stimuli, as they have a heightened dopaminergic response to rewarding cues. It was proposed that this sensitisation is driven by changes to the mesolimbic system in some people with PD. The exact mechanism behind these changes is unknown, but O'Sullivan et al. (2011) proposed that dopaminergic medications sensitise the mesolimbic system to rewards in susceptible individuals. However, research also shows that impaired reward learning is present in people with PD that are not medicated, potentially demonstrating that changes to reward learning observed in PD may result from the PD pathology itself (van der Vegt et al., 2013).

An alternative viewpoint is that changes to the ventral striatum resulting from PD affect delay discounting rather than reward responsiveness. Delay discounting is when a person prefers small immediate rewards rather than waiting for larger rewards and is closely linked to impulsivity (Price, Lee, & Higgs, 2013). Housden,

O'Sullivan, Joyce, Lees, and Roiser (2010) found that their PD participants with ICDs had intact reward learning compared to PD and healthy control groups, however the PD ICD group did demonstrate greater delay discounting. These results suggest that ICDs in PD may be driven by a heightened preference for immediate rewards rather than deficits in reward learning. Housden et al. (2010) put forward the amplified delay discounting may be due to dopaminergic changes in the ventral striatum, because this structure is important for encoding information regarding delayed rewards.

2.6 Converging viewpoints

There are many different views as to what constitutes impulsivity, but some general principles seem to underlie impulsive behaviours. In their review of approaches to impulsivity, Cross et al. (2011) concluded that impulsivity involves a strong attraction to reward and a weak avoidance of punishment. These two principles are also evident in Gray's (1987) biological basis of impulsivity, which posits that impulsive behaviour arises from the behavioural activation system and the behavioural inhibition system. The activation system is the system that is attracted to reward and initiates approach behaviours, whereas the inhibition system seeks to avoid punishment and initiates avoidance behaviours. Bechara (2005) later developed the Competing Neurobehavioural Decision Systems Theory and proposed that impulsive behaviours result from an interaction between two competing independent systems, a prefrontal inhibitory system and an impulsive limbic system. In support of this neurological basis to impulsive decision making, Ferenczi et al. (2016) have since demonstrated that prefrontal regions and midbrain limbic areas exert control over the ventral striatum to moderate decision making in rats. In their study, prefrontal areas demonstrated a top-down inhibitory role on reward seeking behaviour, and the midbrain dopaminergic neurons had a bottom-up influence to motivate reward seeking behaviour. Based upon the reoccurring idea across a number of domains and areas of research that impulsivity results from an interplay of reward and punishment, it seems reasonable to conceptualise impulsivity as an over-attraction to reward and an under-sensitivity to punishment.

2.7 Impulsivity in PD

As stated in chapter one, heightened rates of impulsive behaviours have been observed in PD (Weintraub et al., 2015). The largest cross-sectional study to date estimated the rate of ICDs in PD to be around 13% (Weintraub et al., 2010), compared to a prevalence of around 1% in the general population (Callesen, Scheel-Krueger, Kringelbach, & Moller, 2013). ICDs in PD have been associated with a lower quality of life and increased depressive symptoms (Phu et al., 2014). The demand placed upon caregivers is also greater when a person has PD and an ICD, compared to those with PD and no ICD (Leroi et al., 2012). However, it is thought that the rate of ICDs in PD is consistently underestimated (Baumann-Vogel et al., 2015; Weintraub et al., 2015). This could be due people not disclosing these behaviours due to embarrassment, a lack of effective screening in clinical practice, and a lack of insight in people with PD to recognise that they have a problem with impulsive behaviours (Weintraub et al., 2015). Without valid and appropriate measures, it is difficult to identify people with PD who may have problematic impulsive behaviours (Okai et al., 2016; Weintraub et al., 2015). Being able to identify and thereby manage problematic impulsive behaviours in PD is a priority for both research and clinical practice (Mestre et al., 2013).

2.7.1 Pathological gambling

Estimates for the prevalence of pathological gambling in PD range from 2% to 8% (Santangelo et al., 2013). In an analysis of epidemiological data, Callesen et al. (2013) found that 3.5% of the 14000+ participants reviewed met the DSM-IV criteria for pathological gambling. Pathological gambling is defined as a persistent engagement in gambling, despite significant negative outcomes resulting from the behaviour (American Psychiatric Association, 2013). Pathological gambling in PD shares many characteristics with addiction, including the underlying neurology driving the behaviour (Clark & Dagher, 2014). Impairments to frontal areas and dopaminergic dysfunction (which affects reward processing) have been linked to pathological gambling in PD (Clark & Dagher, 2014). Santangelo et al. (2009) compared 15 participants with PD and a diagnosis of pathological gambling against matched PD controls (matched for age, gender, and education). Participants completed a number of neuropsychological tests to evaluate executive functions,

which are indicative of frontal functioning. The results revealed that PD participants with pathological gambling performed worse on a number of executive functioning measures. In light of this finding, Santangelo et al. (2009) suggested that impaired frontal functioning may contribute to pathological gambling in PD. In a similar study Voon, Thomsen, Miyasaki, and et al. (2007) did not find a difference in executive functioning performance between PD participants with and without pathological gambling. It has been noted, however, that the controls in this study were significantly older than the PD pathological gambling group. Given that executive functions generally decline with age, this may explain why no significant difference in performance was observed between the two groups (Santangelo et al., 2013).

2.7.2 Hypersexuality

Hypersexuality is one of the more commonly reported ICDs in PD and is more frequently reported among males (Weintraub et al., 2010). Callesen et al. (2013) estimated the rate of hypersexuality in PD to be 3.5%. Hypersexuality can be debilitating for the person with PD and place significant strain on relationships with significant others (Evans et al., 2009). Hypersexuality in PD can manifest in a number of ways, including excessive use of pornography, preoccupation with sexual thoughts, extreme promiscuity, the use of phone sex lines, and soliciting sex workers (Evans et al., 2009). Like pathological gambling, hypersexuality in PD has been related to impaired executive functioning. Vitale et al. (2011) compared people with PD and an ICD (including hypersexuality, pathological gambling, and compulsive eating) to matched controls in terms of executive functioning ability. The hypersexuality ICD group performed significantly worse than all the groups on numerous executive functioning tasks. Vitale et al. (2011) reasoned that these results are indicative of impaired frontal functioning in the hypersexuality group. Politis et al. (2013) examined whether there was a difference in brain activation between 12 PD participants with hypersexuality and 12 PD controls when sexual cues were presented. They found that the 'reward circuity' of hypersexual PD participants (limbic areas, the ventral striatum, and prefrontal areas) demonstrated significantly more activation than the PD control group. This was only the case for sexually rewarding stimuli, neutral stimuli and rewarding stimuli of a non-sexual nature did not reveal a difference in activation. The authors reasoned that the increased activation to sexual stimuli observed in the ventral striatum for the hypersexual

group was likely due to increased dopamine release in that area, which contributes to their hypersexual tendencies.

2.7.3 Binge eating

Binge eating is when a person eats more than is necessary to alleviate hunger, and is characterised by uncontrollable episodes of excessive food consumption (Evans et al., 2009). Callesen et al. (2013) reported that approximately 3% of people with PD meet the criteria for binge eating. A large cross-sectional study by Weintraub et al. (2010) revealed that binge eating in PD is more common in females. Compared to other ICDs in PD, research into binge eating is scarce. Nirenberg and Waters (2006) conducted a small case study on seven people with PD and binge eating. They found that six of the seven participants had young onset PD (age of onset <50). As part of the study, five of the participants reduced or stopped their dopamine agonist treatment. For all of these participants the binge eating behaviours ceased. Based on these findings, Nirenberg and Waters (2006) suggested that dopamine agonists may contribute to the development of binge eating in PD. In addition to exploring hypersexuality in PD, Vitale et al. (2011) also examined the cognitive profiles of people with PD and binge eating issues. Like hypersexuality, binge eating was associated with significantly lower scores on measures of frontal functioning compared to the PD control group. Vitale et al. (2011) suggested that these results indicate that people with PD and binge eating issues have impaired frontal functioning.

2.7.4 Compulsive buying

Compulsive buying is another ICD identified in PD, and is estimated to affect approximately 2.5% of people with PD (Callesen et al., 2013). Compulsive buying is described as excessive shopping for unnecessary items that causes distress to a person, such as financial stress (Cho, Kwan, & Seo, 2008). An important aspect of compulsive buying is that it is beyond the person's control, in that they continue the behaviour despite its negative consequences (Cho et al., 2008). Akin to binge eating, compulsive buying is more common in females with PD (Voon, Gao, et al., 2011). Voon et al. (2010) explored the neurological mechanisms behind altered reward learning in both compulsive buying and pathological gambling in PD. Voon et al. (2010) predicted that activation in the ventral striatum would differ for people with

compulsive buying and pathological gambling compared to PD controls. Participants completed a reward learning task where they had to identify which stimuli would result in a reward and which would result in a punishment. The results revealed that the participants with compulsive buying and pathological gambling demonstrated impaired reward learning in the task (i.e., poorer performance) compared to controls. Moreover, the impulsive PD participants had increased activation in the ventral striatum in response to rewards presented during the task. The authors concluded that disordered reward learning may contribute towards both compulsive buying and pathological gambling in PD, in addition to the sensitised activation in response to rewarding stimuli observed in the ventral striatum.

2.7.5 Punding and hobbyism

Punding refers to stereotyped ritualistic behaviours with little purpose, such as arranging, hoarding, and dismantling objects (Evans et al., 2009). Hobbyism is similar, but involves an intense engagement in more complex behaviours such as reading, computer use, cleaning, or gardening (Callesen & Damholdt, 2017). Both can have a significant negative impact upon a person's wellbeing. Callesen and Damholdt (2017) reported that 10% of their participants with hobbyism and punding spent more than five hours a day engaging in the behaviour. Hobbyism and punding behaviours can lead a person to neglect their own physiological needs (such as eating and sleeping) and not fulfil their social obligations (Evans et al., 2009). Callesen et al. (2013) reported that approximately 4% of people with PD had significant issues with hobbyism and punding. Fasano et al. (2010) suggested that hobbyism and punding are underreported in PD, due to the lack of insight that people with PD have to recognise when these types of behaviours have reached a problematic point.

Hobbyism and punding behaviours are frequently thought to be a consequence of dopaminergic medications (Miwa, 2007). Increased rates of hobbyism and punding in PD have been linked to longer duration and higher doses of dopaminergic treatment, including L-Dopa and dopamine agonists (Miwa, 2007). Whilst the exact pathophysiology underlying these behaviours remains unclear, a recent study by Yoo et al. (2015) revealed that structural changes in the brain could play a role. Yoo et al. (2015) compared PD participants with punding behaviours to PD participants without punding behaviours on a range of measures. The participants completed a series of neuropsychological measures to assess executive functioning

and underwent magnetic resonance imaging (MRI) to assess cortical thickness. The results revealed a trend towards the punding group performing worse on measures of executive function, but the difference was not statistically significant ($P = .086$). The punding group did perform significantly worse on a Stroop task, which is a measure of inhibition and executive function. The imaging results showed that the punding group had significant cortical thinning in the dorsolateral prefrontal cortex and orbitofrontal areas. The authors suggested that these results are consistent with frontal areas modulating punding behaviours via connections to the ventral striatum. They concluded that that impaired functioning of reward circuits, and sensitisation of the ventral striatum due to dopaminergic mediations, are likely the main factors contributing to punding behaviours.

2.7.6 Dopamine dysregulation syndrome

Dopamine dysregulation syndrome in PD involves a person self-administering inappropriately high amounts of dopaminergic medication in excess of that required to manage their motor symptoms (Weintraub et al., 2015). The excessive consumption of dopaminergic mediation is associated with behavioural changes, including impulsivity, mania, aggression, and hypersexuality (Evans et al., 2009). People with dopamine dysregulation syndrome have been known to use multiple doctors to obtain more dopaminergic medications, and typically hoard and hide their dopaminergic medications (Sriram et al., 2013). An accurate rate of dopamine dysregulation syndrome in PD is difficult to identify, as many epidemiological studies have not screened for this type of behaviour (Callesen et al., 2013). Callesen et al. (2013) estimated around 1% of people with PD meet the criteria for dopamine dysregulation syndrome.

Evans, Pavese, et al. (2006) investigated whether dopamine dysregulation syndrome was associated with increased release of dopamine in the ventral striatum. Eight participants with PD and dopamine dysregulation syndrome, and eight participants with PD but no dopamine dysregulation syndrome refrained from taking their dopaminergic medication for 12 hours. All participants then received the exact same dose of L-Dopa and underwent PET scans to measure dopamine release in the ventral striatum. The results revealed that the dopamine dysregulation group had significantly higher levels of dopamine release in the ventral striatum in response to the medication, compared to those participants without dopamine dysregulation

syndrome. Participants also completed a questionnaire to examine their subjective feelings after taking the medication. The dopamine dysregulation group reported a craving for more medication. These findings led Evans, Pavese, et al. (2006) to suggest that people with dopamine dysregulation syndrome have a hypersensitive ventral striatum, whereby more dopamine is released in response to medication. The hypersensitivity of the ventral striatum and the corresponding exaggerated release of dopamine in this area, results in the person craving more of their dopaminergic medication.

2.7.7 Other impulsive behaviours in PD

While the aforementioned behaviours are the most commonly studied impulsive behaviours in PD, other impulsive behaviours have been noted (Maloney, Djamshidian, & O'Sullivan, 2017; Mestre et al., 2013). Enticott and Ogloff (2006) stated that impulsivity can manifest itself in numerous different behaviours. Impulsivity has been linked to a number of risky behaviours in the general population, including aggression, substance use, social irresponsibility, criminality, and unsafe behaviours such as driving without a seatbelt (Braddock et al., 2011; Sharma et al., 2013). Risk-seeking behaviours have also been observed in PD, Avanzi et al. (2008) reported two case studies of thrill-seeking reckless driving in PD. Both individuals were described as having dopamine dysregulation syndrome and had experienced motor vehicle accidents as a result of their reckless driving behaviours. A case study by Bienfait, Menza, Mark, and Dobkin (2010) observed a person with PD who began smoking two packets of cigarettes per day after no previous history of smoking. The smoking started one year after his PD diagnosis and closely followed an increase in his dopamine agonist dose from .5 to 1.5 mg. O'Sullivan, Evans, Quinn, Lawrence, and Lees (2010) described three cases of people with PD who developed reckless generosity, whereby they gave away excessive amounts of money and gifts despite this causing significant financial strain. These case studies illustrate that the impulsive behaviours observed in PD go beyond the behaviours that are more commonly studied in the literature. As a result, PD research and clinical practice that only focuses on the main behaviours (e.g., gambling) that are usually examined in PD risks overlooking impulsive people who do not demonstrate these particular behaviours, but instead demonstrate different impulsive behaviours.

2.8 Reasons for impulsive behaviours in PD

As evidenced by the competing neurobehavioural decisions systems theory, the multiple clinical populations with impulsivity issues, and numerous PD studies, the frontal areas of the brain play an important role in mediating impulsive behaviours. Ferenczi et al. (2016) demonstrated that stimulation of frontal areas corresponds with top down inhibition of activity in the ventral striatum, and a decrease in reward seeking behaviour in rats. As discussed in chapter one, PD is associated with the degeneration of frontal areas and the impairment of abilities dependent on these areas (including executive functions). Braak, Del Tredici, et al. (2003) described how in the latter stages of PD, α-synuclein pathology reaches prefrontal areas and leads to neural degeneration in these areas. In line with this, atrophy of frontal areas has been correlated with increased impulsive behaviours in PD (O'Callaghan, Naismith, Hodges, Lewis, & Hornberger, 2013; Voon, Gao, et al., 2011; Yoo et al., 2015) Furthermore, frontal functioning in PD is further impacted by changes to dopaminergic and cholinergic systems (Gratwicke et al., 2015; Silbert & Kaye, 2010). A recent meta-analysis by Santangelo et al. (2017) looked at differences in executive functioning between people with PD and an ICD, and those with PD and no ICD. The findings indicated that people with PD and an ICD are impaired in several domains of executive functioning compared to those with no ICD, including set-shifting, visuospatial ability, and decision making. This is congruent with the idea that impaired frontal areas could contribute to impulsive behaviours in PD.

Research in PD has demonstrated that impulsive individuals show increased activation in the ventral striatum in response to rewarding cues compared to non-impulsive individuals (Evans, Pavese, et al., 2006; Vitale et al., 2011; Voon et al., 2010). In their meta-analysis, Wang et al. (2016) revealed that in the general population, the ventral striatum activates in response to rewarding stimuli and drives approach behaviours. The overdosing theory could explain why some people with PD demonstrate altered activation in the ventral striatum (Averbeck et al., 2014). The overdosing theory states that, while dopaminergic medications help to replenish depleted dopamine in areas such as nigrostriatal pathways, it overdoses relatively intact areas with excess dopamine (Dagher & Robbins, 2009). In PD the ventral striatum remains relatively undamaged compared to other parts of the basal ganglia

(Cools, 2006; Cossu et al., 2018). Therefore, dopaminergic medications could lead to an excess of dopamine in the ventral striatum for people with PD (Cossu et al., 2018). It is thought that this excess dopamine in the ventral striatum increases the salience of rewards for some people with PD, and leads to structural changes which further sensitise the ventral striatum to rewarding stimuli (Averbeck et al., 2014; Dagher & Robbins, 2009). In support of this, a recent imaging study by Claassen et al. (2017) demonstrated that when PD participants with an ICD were administered dopamine agonists, they had a significant increase in blood flow to the ventral striatum (indicative of increase dopamine). In contrast, the PD participants without an ICD did not show any significant change in blood flow in response to the dopamine agonists. Dopaminergic medications may also impair the ability to learn from punishment, as learning from punishment relies on a decrease in dopamine in the ventral striatum (Elizabeth et al., 2013). The net result for those with PD on dopaminergic medications may be that some people are over-attracted to reward (due to a sensitised ventral striatum) and under-sensitive to punishment (due to impaired frontal functioning). Hence, some people with PD may be particularly susceptible to engagement in impulsive behaviours.

2.9 Measuring impulsive behaviours in PD

Early research adopted a number of methods to measure impulsive behaviours in PD (Mestre et al., 2013; Weintraub et al., 2009). Self-report questionnaires, such as the South Oaks Gambling Screen (Lesieur & Blume, 1987), have been used to identify specific ICDs like pathological gambling (Weintraub et al., 2009). Early studies that sought to identify issues more specific to PD, such as punding behaviours, developed interviews to identify people with these behaviours (Evans et al., 2004). One measure used in PD research that screens for multiple impulsive behaviours is the Minnesota Impulsive Disorders Interview (MIDI; Mestre et al., 2013). The MIDI is a semi-structured diagnostic interview developed by Christenson et al. (1994) to identify ICDs based upon the DSM III-R. The MIDI asks about binge eating, compulsive sexual behaviour, gambling, pyromania, intermittent explosive disorder, skin picking, compulsive buying, trichotillomania (compulsively plucking hair from the body), and kleptomania (stealing without an apparent need for the stolen good). Each ICD is assessed using a general question (e.g., “Have you ever

stolen anything?"), which if answered affirmatively is followed by a series of questions about the specific behaviour (Adam, Richoux, & Lejoyeux, 2008). The MIDI does not, however, consider impulsive issues more specific to PD like punding and dopamine dysregulation syndrome (Weintraub et al., 2009). Rather, the MIDI focuses upon the narrow range of ICDs identified in the DSM III-R, several of which have not been included in the DSM-5 (Black, 2014). Furthermore, the MIDI lacks clear instructions for administering and scoring the measure (Mestre et al., 2013).

As no comprehensive measure for impulsive behaviours in PD existed at the time, Weintraub et al. (2009) created the Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease (QUIP). They sought to create a measure to use in research and clinical practice that would capture a range of impulsive behaviours observed in PD. The QUIP has a couple of advantages over diagnostic interviews. It is brief, and by virtue of being questionnaire based, it reduces the potential for embarrassment which may increase the disclosure of impulsive behaviours. The QUIP considers four ICDs mentioned in the DSM-5 commonly seen in PD, which are pathological gambling, hypersexuality, compulsive buying, and compulsive eating. The QUIP also screens for the following impulsive behaviours seen in PD which are not classified as ICDs, punding, hobbyism, dopamine dysregulation syndrome, and walkabout (restlessness and a persistent urge to walk). The QUIP was later revised by Weintraub et al. (2012) to simultaneously screen for impulsive behaviours in PD, and assess the severity of the reported behaviours (QUIP-RS). A severity rating scale for each behaviour was included, and the revised version provided cut-off scores to determine whether or not a behaviour could be considered problematic. Due to the high degree of overlap between the two behaviours, punding and hobbyism were combined in the QUIP-RS to create a single score, which indicates whether a person has a significant issue with hobbyism and/or punding. Due to no walkabout cases being detected in studies validating the QUIP (Weintraub et al., 2009), this behaviour was dropped from the QUIP-RS.

The QUIP and the QUIP-RS are regarded as the most comprehensive screening instruments for ICDs in PD (Pablo Martinez-Martin et al., 2016). The QUIP/QUIP-RS are the only self-report instruments that have been validated for identifying ICDs and related impulsive behaviours in PD (Pablo Martinez-Martin et al., 2016). Although the QUIP-RS is arguably one of the most established screening measures for impulsive behaviours in PD, only a handful of studies have assessed its

psychometric properties. Recently Martinez-Martin, Rodriguez-Blazquez, and Catalan (2018) evaluated the QUIP-RS and found that the measure had satisfactory internal consistency. Probst et al. (2014) evaluated a translated version of the measure in a German-speaking sample. They found that the QUIP-RS demonstrated good sensitivity, but the specificity of the measure was lower than in the original validation by Weintraub et al. (2012). Probst et al. (2014) found that the specificity of the QUIP-RS ranged from .62 (punding), to .92 (gambling). In comparison, the original paper by Weintraub et al. (2012) found that that all assessed behaviours had a specificity >.8. The QUIP therefore seems to suffer from high false positive rates (Probst et al., 2014). Probst et al. (2014) concluded that while the QUIP-RS does appear to be a useful screening measure, further research evaluating the instrument is required.

Okai et al. (2016) recently developed the Parkinson's Impulse-Control Scale (PICS), a semi-structured interview designed to screen for ICDs in PD and assess their impact on the person's wellbeing. The PICS screens for the same impulsive behaviours as the QUIP-RS. Okai et al. (2016) acknowledged that the QUIP is the most widely used assessment for impulsive behaviours in PD. However, they argued that being a self-report measure the validity of the QUIP-RS is limited by the insight of the respondent. The advantage of a clinician administering an interview is that they are able to provide a more detailed assessment of the person's situation, and probe further if they suspect that problematic impulsive behaviours are present (Okai et al., 2016). However, diagnostic interviews depend on the person being comfortable with disclosing their impulsive behaviours in an interview setting, which has been noted as an issue in assessing impulsive behaviour in PD due to the potentially embarrassing nature of these behaviours (Weintraub et al., 2015).

2.9.1 Considerations

Frontal areas of the brain are impaired in PD as a result of PD α-synuclein pathology and disruptions to neurotransmitter systems. This has implications for the use of self-report measures, as a person's ability to have insight into their own behaviours is heavily reliant on the prefrontal cortex (Fletcher & Carruthers, 2012). Lesions to prefrontal areas have been associated with reduced insight (Kikyo, Ohki, & Miyashita, 2002; Schnyer et al., 2004). Correspondingly, research has shown that people with executive functioning impairments in PD also demonstrate reduced

insight (Kudlicka, Clare, & Hindle, 2013). It has been suggested that reduced insight in PD may impair the ability of people to accurately report their own impulsive behaviours, and may contribute to the under diagnosis of these behaviours in PD (Baumann-Vogel et al., 2015; Fasano et al., 2010). As is clear from the evidence presented in this chapter, decreased function in frontal areas contributes significantly to impulsive behaviours. Therefore, people who are at a high risk for problematic impulsive behaviours are also those who are most likely to have reduced insight and an impaired ability to recognise and report their impulsive behaviours. This is a significant issue, as the management of ICDs in PD is reliant on these behaviours being identified as soon as possible to minimise the negative impact they may have (Ramirez-Zamora et al., 2016).

2.9.2 Alternative means of measurement

To address some of the issues with impaired insight in PD, the use of nominated informants has been suggested (Baumann-Vogel et al., 2015; Ramirez-Zamora et al., 2016). The nominated informant may be a spouse, family member, carer, or close friend who is able to provide some insight on the behaviour of the person with PD (Ramirez-Zamora et al., 2016). Asking a nominated informant circumvents some of the issues associated with reduced insight in PD, as the identification of problematic impulsive behaviours no longer solely relies on the person self-reporting their own behaviours (Baumann-Vogel et al., 2015). Furthermore, this strategy goes some way towards identifying problematic impulsive behaviours if a person with PD is purposefully not disclosing their behaviours to practitioners or researchers due to guilt or embarrassment (Ramirez-Zamora et al., 2016; Weintraub et al., 2012). It is important to note that although the nominated informant is an invaluable source of information, the self-reporting of impulsive behaviours remains important. Hence, measures such as the QUIP-RS have been designed to be completed by both the person with PD and/or a nominated informant (Weintraub et al., 2012).

Laboratory based measures are another alternative means of assessing impulsive behaviours (Enticott & Ogloff, 2006). Such measures involve observing impulsive behaviours in an experimental setting, typically using tasks designed to measure impulsive decision making (Emery & Levine, 2017). The aim of laboratory based measures of impulsivity is to recreate decision making situations that will

reveal the traits which drive a person's behaviours (Enticott & Ogloff, 2006). The advantage of laboratory based tasks is that they do not depend on the self-reporting of behaviours, and as such do not require insight on behalf of the participant (Sharma et al., 2014). Furthermore, they are objective and are not easily biased by the respondent (Enticott & Ogloff, 2006). Laboratory measures of impulsivity have previously been associated with engagement in 'real-world' risk taking behaviours, which demonstrates the ecological validity of these measures (King, Patock-Peckham, Dager, Thimm, & Gates, 2014; Lejuez et al., 2007). A limitation of laboratory based measures is that they are often conducted in a neutral setting, which may not replicate the nature of impulsive decisions in the real-world. Real-world impulsive decisions often involve a degree of emotion and stress that may not be replicated in a laboratory setting (Enticott & Ogloff, 2006). Laboratory measures can also be subject to task impurity, meaning that they do not measure impulsivity alone, but capture performance in numerous domains simultaneously (Enticott & Ogloff, 2006). For example, to complete some impulsivity tasks successfully, participants are required to recall previous trials and engage in problem solving. Therefore, these tasks typically also measure memory performance and executive functioning (King et al., 2014). Nonetheless, it has been suggested that to comprehensively assess impulsivity, research would benefit from using both self-report and laboratory based impulsivity measures (Sharma et al., 2014).

2.10 Thesis research objective

This research project investigated the currently used methods to examine impulsivity in PD. PD provides many unique challenges that complicate the measurement of impulsive behaviours. This thesis examined how these challenges may affect the ability of commonly used measures to adequately assess impulsivity in PD. Potential solutions to these issues are also explored to improve future efforts to examine impulsivity in PD. By investigating these areas of impulsivity in PD, this thesis sought to further the understanding of the nature of impulsivity in PD. Specific aims and hypotheses are outlined in the subsequent study chapters.

Chapter 3 Aims, rationale and general methodology

The data for all of the studies in this thesis was collected simultaneously. Before each study is reported in its entirety, a brief overview of each study is provided followed by a general method section. The general method section contains an overview of all the measures employed in the studies. This chapter also contains information about the participants and the procedure employed to collect the data for all of the studies. In this way, the thesis avoids unnecessary repetition of methods.

3.1 Overview of studies

3.1.1 Study 1

To explore whether self-reported impulsivity as measured by the QUIP-RS and the BIS/BAS scale is consistent with risky behaviours in PD.

Current research investigating impulsivity in PD focuses on the identification of several problematic impulsive behaviours commonly seen in PD (four ICDs and three related impulsive behaviours; Weintraub, David, Evans, Grant, & Stacy, 2015). Consequently, impulsivity issues assessed in PD rarely extend beyond these behaviours (Mestre et al., 2013). In the general population, impulsivity has been linked to a myriad of problematic behaviours such as violence, substance abuse, and social irresponsibility (Sharma et al., 2013). Case studies have confirmed that similar behaviours exist in the PD population (Avanzi et al., 2008; Bienfait et al., 2010; O'Sullivan et al., 2010). In the non-PD literature, such behaviours have been shown to significantly impact on people's lives and are a leading cause of death in developed nations (Braddock et al., 2011).

To assess a broader range of impulsive behaviours in PD, the Screening for Risky Behaviours Battery (SERB) was compiled for this project. The SERB seeks to assess impulsive behaviours commonly identified in non-PD impulsivity literature. The focus of the SERB is to screen for the frequency of impulsive risky behaviours, rather than requiring the participant to make a subjective judgement about whether the behaviour is problematic or not.

One of the most comprehensive measures for impulsive behaviours in PD is the Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease Rating Scale (QUIP-RS). The QUIP-RS is designed to identify four ICDs and three

related impulsive behaviours commonly seen in PD (Weintraub et al., 2012). Due to the QUIP-RS' focus on these specific behaviours, it is reasonable to suggest that it may overlook other impulsive behaviours that people with PD have (as identified by the SERB). In contrast, the BIS/BAS scale by Carver and White (1994) measures attraction to reward and fear of punishment rather than specific behaviours. As discussed in chapter two, conceptualising impulsivity in this way is common across many different domains of research. For the purposes of the study one, we predicted that the BIS/BAS scale would relate well to the impulsive outcomes as assessed by the SERB. The study was exploratory in nature, and examined the relationships between the QUIP-RS (ICD measure), the BIS/BAS scale (reward/punishment sensitivity measure), and engagement in impulsive behaviours (SERB).

3.1.2 Study 2

To explore the impact of insight on the relationship between self-report measures of impulsivity (QUIP-RS, BIS/BAS) and self-reported risky behaviours in PD.

This study comprised two parts. **Part 1:** Examined how insight differs between those identified by the QUIP-RS as having an Impulse Control Disorder (ICD) and those with no ICD. Previous research has suggested that those with impulsivity issues in PD may lack proper insight into their impulsive behaviours, but research investigating this relationship is limited (Baumann-Vogel et al., 2015; Fasano et al., 2010). Mack et al. (2013) investigated how insight in PD differed between participants with an ICD and participants without an ICD (n = 34) using the Beck Cognitive Insight Scale. They predicted that those with an ICD would have reduced insight. However, the results indicated the opposite. The PD participants with an ICD self-reported better insight than those without an ICD. Mack et al. (2013) stated that their results may be an anomaly due to the limited sample used, and concluded that larger scale studies are required. To clarify this situation, study two examined whether participants with an ICD versus no-ICD (QUIP-RS) differed on the Beck Cognitive Insight Scale (BCIS), a measure of insight. Therefore, by using a larger sample size this study aimed to provide a greater understanding of insight across ICDs in PD.

Part 2: Examined whether the relationship between self-reported impulsivity (QUIP-RS and BIS/BAS scale) and frequency of impulsive behaviours (SERB) is

moderated by insight. The SERB has been designed to be as objective as possible (by asking the individual to report the frequencies of behaviour) and does not require the individual to make a subjective assessment of the impact of their behaviours. It is therefore anticipated that the SERB will not be dependent on insight. In comparison, both the QUIP-RS and BIS/BAS are subjective and require some degree of insight for the accurate reporting of the 'problem' behaviours (e.g., "Do you have difficulty controlling the following behaviours", "I have very few fears compared to my friends").

It was predicted that lower insight would be associated with a decreased relationship between self-reported impulsivity (QUIP-RS and BIS/BAS) and risky impulsive behaviours (SERB), indicating that insight moderates the relationship between self-reported impulsivity and reported risky behaviours. This would demonstrate that reduced insight in PD impacts upon the ability to correctly self-report problematic impulsive behaviours in subjective measures.

3.1.3 Study 3

Exploring the validity of behavioural impulsivity tasks in PD

This study comprised three parts. Behavioural measures of impulsivity typically do not correlate well with self-reported assessments of impulsivity (Cyders & Coskunpinar, 2011; Gomide Vasconcelos, Sergeant, Corrêa, Mattos, & Malloy-Diniz, 2014). However, both self-report and behavioural measures have demonstrable value in predicting engagement in impulsive behaviours (King et al., 2014). Therefore, behavioural tasks may be a useful means of measuring impulsive behaviours in PD that also overcome some of the limitations of self-report assessments. Research has suggested that aggregating scores from multiple behavioural measures could provide a more useful indication of impulsivity (Duckworth & Kern, 2011; King et al., 2014). According to the principle of aggregation, summing multiple measures provides a more accurate assessment of a construct than using any one measure on its own (Rushton, Brainerd, & Pressley, 1983). By aggregating scores from multiple behavioural measures of impulsivity, a unitary representative score of impulsivity can be produced. In their meta-analysis of impulsivity measures, Duckworth and Kern (2011) advocated the use of this approach for behavioural tasks. Using this approach may improve the relationship between objective measures and self-report measures of impulsivity (Dougherty,

Mathias, Marsh, & Jagar, 2005; King et al., 2014; Rushton et al., 1983). For study three, a composite score was generated for three objective behavioural measures of impulsivity to be used in the analyses. The objective composite score of behavioural impulsivity was calculated using the Iowa Gambling Task, Balloon Analogue Risk Task, and the Probabilistic Reward Task.

Part 1: A factor analysis was performed on the behavioural tasks to explore how the tasks related to one another and to determine whether they load onto a common factor. This will also indicate whether the behavioural tasks are capturing similar or separate constructs.

Part 2: Investigated the relationship between the objective composite score of impulsivity and risky behaviours (SERB). This enabled us to determine whether laboratory based measures of impulsivity capture an individual's tendencies toward impulsive behaviours. If laboratory based measures of behavioural impulsivity do have a significant relationship with these behaviours, they could be used to identify 'at risk' individuals.

Part 3: Examined whether the composite score for the behavioural tasks related to self-report measures of impulsivity. The role of insight in this relationship was also explored. It was proposed that the impaired insight associated with PD reduces the accuracy of self-reported impulsivity (i.e., the lower the person's insight, the greater the discrepancy between how impulsive they rate themselves and the impulsivity they demonstrate on the objective behavioural tasks). It was predicted that insight will moderate the relationship between the objective behavioural composite score and self-reported measures of impulsivity (QUIP-RS, BIS/BAS). This would indicate that the insight of an individual needs to be taken into account when conducting assessments for impulsive behaviour.

3.1.4 Study 4

Nominated informant appraisals for assessing impulsivity in PD

To overcome the issues associated with reduced insight in PD, research suggests that informants should be asked about their perception of a person's behaviour (Baumann-Vogel et al., 2015). The QUIP-RS can be completed by an informant (Weintraub et al., 2012). For this study, participants with PD completed the self-report version of the QUIP-RS, and a nominated informant (spouse, caregiver, friend, etc.) completed the alternative version. An impulsivity discrepancy

score (self-report – nominated informant report) was calculated to capture how much the self-report and nominated informant accounts of impulsivity differed (if at all). This is important, as the current study aimed to determine which source of information is the most useful when the informant and the person with PD disagree. If both informants have a similar appraisal, there is no use in comparing them. Moderation models were used to evaluate whether the self or the nominated informant reported impulsivity best related to the objective composite score, when the discrepancy score was taken into account. Moderation models were also used to determine whether the self or the nominated informant reported impulsivity best related to the risky impulsive behaviours (SERB), when the discrepancy score was taken into account. This determined which account (self or nominated informant) most accurately reflected an individual's objective impulsivity and risky impulsive behaviours. The findings of this study may help to inform research and clinical practice as to whether nominated informants are a useful source of information for impulsive behaviours in PD.

3.2 Research design

We used a cross sectional research design to collect data for the four studies included in this thesis. The PD participants completed a number of questionnaires, three behavioural measures of impulsivity, and a clinical assessment of their motor symptoms. The nominated informants completed a series of questionnaires which required them to comment on the behaviour of the person with PD.

3.3 Power analysis and sample size

Past research comparing self and informant reported impulsivity by Papay et al. (2011) comprised 71 participants and a similar study by Baumann-Vogel et al. (2015) 64 participants. The statistical tests used in both studies do not allow for a calculation of effect size. Mack et al. (2013) investigated differences in insight between participants with an ICD vs. no-ICD and found a significant difference with a large effect size ($d = 1.05$). Therefore, to detect differences in insight across ICDs in PD ($\alpha = .8$) a small sample size of more than 8 is required. Limited studies are

available which compare behavioural measures of impulsivity to self-reported impulsivity, however those that have been conducted have generally found a small to moderate effect size (Franken, van Strien, Nijs, & Muris, 2008; Lejuez et al., 2007; Lejuez, Aklin, Zvolensky, & Pedulla, 2003; Lejuez et al., 2002; Suhr & Tsanadis, 2007). Based on these studies, a sample size of approximately 85 would be needed to detect a small to moderate association between behavioural impulsivity tasks and self-report measures. Therefore, the present study aimed to recruit approximately 85 participants, however due to time constraints recruitment ceased after 66 participants had taken part.

3.4 Participants

A total of 66 participants with PD took part in the study and 64 nominated informants (two of the participants did not have informants who were available to take part). Recruitment started in July 2016 and ended September 2017. Participants were recruited via several avenues. To advertise the research project and recruit participants, several presentations were given to Parkinson's Western Australia (PWA) support group meetings around the Perth area and to PWA's annual general meeting. The research project was also presented at an open day for Parkinson's research at Curtin University, which included an invitation to participate in the research. Two bulk mail-outs with recruitment flyers were posted to people with PD who had previously consented to being contacted about PD research opportunities. Invitations to participate were also published in the Parkinson's Western Australia newsletters on several occasions. Two interviews on local radio stations were also conducted to advertise the study. Two news articles were written about the research project with invitations to participate. One article was written for a local newspaper, and the other for a website (both of which are targeted towards an older adult demographic). A further two articles also advertised the study, one was written for a local high school newsletter, and the last was for an annual newsletter regarding PD research at Curtin University. In total, 68 people with PD contacted the lead researcher to indicate their interest in the research project, two decided not to take part after they had been informed about the participation requirements.

Participants must have been diagnosed with idiopathic PD by a neurologist or physician, it is standard practice for PD to be diagnosed according to United

Kingdom Parkinson's Disease Society Brain Bank criteria (Hughes et al., 1992). Participants who demonstrated dementia symptoms as indicated by the screening measure (Telephone Interview for Cognitive Status-30) were excluded. The demographic characteristics of the sample are summarised in Table 3.1. The L-dopa equivalent dose was calculated according to Tomlinson et al. (2010). The presence of an ICD was determined according to Papay et al. (2011), that is, participants were categorised as having an specific ICD if both the person with PD and their nominated informant indicated the presence of that ICD on the QUIP-RS.

Table 3.1 Sample demographic characteristics

	Total Sample (n = 66)	ICD (n = 32)	No ICD (n = 34)	p-value^
Gender (%)				.221
Male	52	59	44	
Female	48	41	56	
Age (%)				.112
M (SD)	66.3 (9.2)	64.5 (9.5)	68 (8.6)	
45-54	9	13	6	
55-64	35	41	29	
65-74	38	31	44	
75-84	15	16	15	
85+	3	0	6	
Age at diagnosis (years)				
M (SD)	58.1 (10.8)	55.5 (12.3)	60.6 (8.7)	.056
Time since diagnosis (years)				
M (SD)	8.2 (5.5)	8.9 (6.1)	7.4 (4.8)	.272
Medication				
Taking DA n(%)[a]	43 (65%)	24 (75%)	19 (56%)	.103
L-Dopa Eq dose[b]	868.8 (537.2)	983.6 (626.3)	760.9 (418.7)	.092
UPDRS score				
M (SD)	32.2 (12.7)	35.3 (11.0)	29.1 (13.5)	.046*

Note: percentages may not sum to 100 due to rounding
[a]*Currently taking dopamine agonists.*
[b]*Current Levodopa equivalent (mg)*
**p < .05*
^Independent samples t-tests were conducted to compare the ICD and no-ICD groups on the demographic variables (chi-square test used for DA %)

3.5 Apparatus

The behavioural tasks were all administered on a Sony Vaio laptop computer with a 16.4 inch display. The Probabilistic Reward Task was administered using E-Prime software, and the task itself was provided by Dr Diego A Pizzagalli from the Department of Psychiatry at Harvard Medical School. The Balloon Analogue Risk Task was provided by Dr Carl Lejuez from the Department of Psychology at the

University of Kansas. Lastly, the Iowa Gambling Task was purchased through Psychological Assessment Resources and uses the 'PAR software' provided with the purchase.

3.6 Measures

Demographic questionnaire: Demographic information about participants was collected via questionnaire (see Appendix A). Information regarding age, relationship status, occupation (past or present), age of PD onset, familial history of PD, medication use, and co-morbid medical issues was gathered.

Telephone Interview for Cognitive Status-30 (TICS-30): Participants were screened for significant cognitive impairment (i.e., dementia) using the TICS-30 (see Appendix B; Brandt, Spencer, & Folstein, 1988). The TICS-30 consists of eight items examining language, concentration, mathematical ability, orientation, and short-term memory (Brandt et al., 1988). The TICS-30 has validity in differentiating between participants with normal cognitive abilities and those with dementia (Knopman et al., 2010). The TICS-30 relates well to other widely used assessments of cognitive impairment, such as the Mini-Mental State Examination (Fong et al., 2009). The test-retest reliability of the TICS-30 is excellent, ranging from r = .86-.91 (Desmond, Tatemichi, & Hanzawa, 1994; Ferrucci et al., 1998). To be included in the study, participants had to score 18 or above on the TICS-30. Scores below 18 indicate the presence of 'significant cognitive impairment'(Fong et al., 2009).

Movement Disorder Society Revision of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS) Section III: The revised UPDRS was developed by Goetz et al. (2008) as a comprehensive measure of PD (see Appendix C). Section III was used to assess the motor symptoms of PD. The UPDRS is considered to be the gold standard for the assessment of PD symptoms and is widely used for both clinical and research purposes (Pablo Martinez-Martin & Forjaz, 2006; Ramaker, Marinus, Stiggelbout, & van Hilten, 2002). Participants are rated on a scale of 1-4 for 26 different movements, (Goetz et al., 2008). A sum of scores is calculated, which ranges from 0 (no symptoms of PD) to 104 (severe PD symptomology). Section III of the UPDRS demonstrates excellent retest reliability, r = .90, and good inter-rater reliability (Ramaker et al., 2002). The lead researcher was formally trained in the

administration of the UPDRS section III, and a quarter of the assessments were double-scored by an additional trained researcher to ensure consistency.

The Behavioural Inhibition System/Behavioural Activation System Scale (BIS/BAS): Is a self-report measure developed by Carver and White (1994) to measure the behavioural inhibition and activation systems proposed by J. A. Gray (1987), and comprises four subscales (see Appendix D). BIS is assessed using the 'punishment sensitivity scale' and is a univariate outcome. The BAS is multivariate and has three subscales: the drive scale, the fun scale, and the reward responsiveness scale. Alternative factor structures have been proposed for the BIS/BAS scale. Poythress et al. (2008) proposed that the BIS should be split into two separate factors. Another study by J. D. Gray, Hanna, Gillen, and Rushe (2016) also supported this alternative factor structure. Based upon this, the BIS will be assessed using both the original single factor structure, and the alternative two factor structure. The measure is considered short (20 items) and displays reasonable test-retest reliability for BIS (r = .66), drive (r = .66), reward responsiveness (r = .59), and fun seeking (r = .69; Carver & White, 1994). The BIS/BAS scale has also demonstrated validity with other measures, such as the Eysenck Personality Questionnaire (Jorm et al., 1998). The BIS/BAS scale has been used in a number of PD studies, including research investigating reward sensitivity (Boksem, Tops, Wester, Meijman, & Lorist, 2006; Cools, Altamirano, & D'Esposito, 2006; Jordan, Zahodne, Okun, & Bowers, 2013).

The Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease–Rating Scale (QUIP-RS): This scale was developed by Weintraub et al. (2012) and is used to identify ICDs in PD (see Appendix E). The QUIP-RS builds upon previous measures, such as the Minnesota Impulsive Disorders Interview, by including punding behaviours and dopamine dysregulation syndrome (Weintraub et al., 2012). The QUIP-RS examines six impulsive behaviours commonly observed in PD, including pathological gambling, hypersexuality, compulsive buying, compulsive eating, punding/hobbyism, and dopamine dysregulation syndrome. The QUIP-RS requires participants to respond to four questions for each behaviour using a rating scale. For example, the participants rate how much the following statements apply to them for each assessed behaviour (e.g., "How much do you think about the following behaviours", or "Do you have difficulty controlling the following behaviours"). Cut-off scores are provided to determine if a behaviour is clinically

significant, or a total score of impulsivity can be calculated. It should be noted that the QUIP-RS is not a formal diagnostic instrument; it is used to indicate the possible presence of an ICD. The measure has a good test re-test reliability ($r > .9$), and has demonstrated good validity with similar measures (Weintraub et al., 2012). A recent validation by Martinez-Martin et al. (2018) reported that, over a one month period, participants' scores on the QUIP-RS differed significantly compared to their scores at baseline. This raises questions about the test re-test reliability of the measure. Martinez-Martin et al. (2018) also found that the QUIP-RS correlated well with other assessments of ICDs, and demonstrated good internal consistency for the assessed behaviours. The QUIP-RS has been designed to be completed by people with PD and/or a nominated informant (Weintraub et al., 2012). The QUIP-RS has been used extensively, and is considered to be one of the most comprehensive self-report measures for identifying ICD and related behaviours in PD (Pablo Martinez-Martin et al., 2016).

Screening for Risky Behaviours Battery (SERB): The SERB has been created for the purposes of this research project as no measure that assesses a broad range of commonly identified impulsive behaviours that was needed for this research project could be found in the literature (see Appendix F). The purpose of the SERB is to measure a range of risky behaviours that are frequently identified in the impulsivity literature. Previous research has sought to achieve the same objective, including Lejuez et al. (2002) and Sharma et al. (2013) who used an established measure for each impulsive behaviour they examined (gambling, alcohol consumption, etc.) to create a battery of measures which identified 'real-world' impulsive behaviours. Therefore, the same method was employed to develop the SERB. Due to the difficulties with insight in PD (Baumann-Vogel et al., 2015), the SERB was designed to be as objective as possible, thereby minimising the insight required to accurately complete the measure.

The following impulsive risky behaviours are frequently identified in impulsivity literature: Alcohol consumption, tobacco consumption, drug use, gambling, and violence/aggression (Braddock et al., 2011). The Alcohol Use Disorders Identification Test-Consumption (AUDIT-C) is used in the SERB to measure alcohol consumption. The AUDIT-C is an established measure for assessing alcohol consumption (Bradley et al., 2007), and by focusing on alcohol consumption it remains as objective as possible. Tobacco consumption was be assessed using the

Heaviness of Smoking Index (HSI) by Heatherton, Kozlowski, Frecker, Rickert, and Robinson (1989). The HSI has demonstrated sound psychometric properties (Borland, Yong, O'Connor, Hyland, & Thompson, 2010). Drug consumption was assessed using the same method employed by Lejuez et al. (2002). The question asks the participant to indicate which classes of drug (if any) they have tried over the last 12 months (such as marijuana, stimulants, etc.).

Gambling behaviours were assessed using the South Oaks Gambling Screen (SOGS) by Lesieur and Blume (1987), an established measure with good psychometrics (Abbott & Volberg, 2006). To maintain objectivity, only one section from the measure was used, which assesses the frequency of gambling behaviour. Violence and aggression will be examined using the Brief Aggression Questionnaire (Webster et al., 2014). The measure has demonstrated convergent validity with similar measures and has an sound test re-test reliability of r = .68-.80 (Webster et al., 2015). The questionnaire has also been found to predict behavioural aggression over time (Webster et al., 2015).

More general impulsive behaviours such as stealing, or using the phone whilst driving, were assessed using questions from the Centres for Disease Control Youth Risk Behaviour Surveillance System. The questions are designed to identify general risk taking behaviours in daily life (Centers for Disease Control and Prevention, 2015). Previous research has used questions from the Youth Risk Behaviour Surveillance System for this purpose (Braddock et al., 2011; Lejuez, Aklin, Zvolensky, et al., 2003). The survey items demonstrate good reliability (Brener et al., 2002).

Finally, there is anecdotal evidence that some individuals with PD often make impulsive and socially inappropriate comments (Poletti, Enrici, Bonuccelli, & Adenzato, 2011; Yu & Wu, 2013). To detect these behaviours, the questions used in the SERB were adapted from impulsivity research (A. Campbell & Muncer, 2009) and Tourette's syndrome research (Kurlan et al., 1996). No assessment of these behaviours has been included in PD research, so inclusion of such questions is entirely novel in this study.

There are seven sections in the SERB. To give each section an equal weighting, each section was scored out of 10 points (maximum score of 70 in total). The higher the score, the more impulsive behaviours that person has indicated they perform. Creating a composite score provide a general indication of a person's

engagement in the impulsive behaviours examined. It must be noted that the Brief Aggression Questionnaire used a Likert scale for the measure ranged from 1-5. As the Brief Aggression Questionnaire has 12 items, this provided a minimum score of 12. To ensure that all sections have a minimum score of zero, we subtracted 12 from the total score of the brief aggression questionnaire. This ensures that the section concerning aggression would not be given a higher weighting (than other sections) in the total (overall) SERB score. Due to the SERB being developed for the current study, validity and reliability statistics are not available for this measure. The subsequent study chapters that employ the SERB and examine the relationships between this measure and pre-exiting measures of impulsivity provide some preliminary evidence regarding the validity of this newly developed measure.

Beck Cognitive Insight Scale (BCIS): The BCIS was developed by Beck, Baruch, Balter, Steer, and Warman (2004) to assess a person's 'cognitive insight' (see Appendix G). The BCIS is commonly used to assess insight (Pineau et al., 2016). The measure comprises 15 items and responses are made on a four-point Likert scale ranging from 'do not agree at all', to 'agree completely'. The measure has two factors, self-reflectiveness and self-certainty. A composite score is calculated (self-reflectiveness minus self-certainty) which determines how effectively an individual can introspect. The measure demonstrates sound validity and correlates well with other measures of insight. The measure is also able to distinguish clinical populations who experience impaired insight from healthy controls (people with schizophrenia vs people without schizophrenia; Beck, 2004). Martin, Warman, and Lysaker (2010) reported that the measure has good test-retest reliability, r= .77 for self-reflectiveness, r = .86 for self-certainty and r =.87 for the composite score. Normative data is also available for the measure (Buchy, Brodeur, & Lepage, 2012). The BCIS has been used to assess insight in PD previously (Mack et al., 2013). It is worth noting that alternative factor structures for the BCIS have been proposed. Kao and Liu (2010) examined the psychometric properties of the BCIS Scale and found that the original factor structure did not fit their data well. They proposed an alternative factor structure that still contained the self-reflectiveness and self-certainty subscales, but 2 items from each subscale were assigned to the opposite subscale to reflect the factor loadings they observed.

The Iowa Gambling Task (IGT): Was used to measure impulsivity objectively. Bechara, Damasio, Tranel, and Damasio (1997) designed the task to

simulate real life risk taking. The IGT was originally designed to investigate cognitive changes in decision making after prefrontal lesions. However, the IGT has been used in extensively in PD research to examine disease-related changes in behaviour (Evens, Hoefler, Biber, & Lueken, 2016). The participant starts with $2000 and is required to win the most amount of money possible. The participant has to choose between four decks of cards and turning a card provides a reward. However, on random occasions the turn of a card incurs a penalty. Decks A and B of the task have a large reward and a large penalty, whereas decks C and D have a smaller reward and a lesser penalty. It is advantageous in the task to choose the 'safe decks' (decks C & D) as although they offer less immediate reward, the penalties are proportionally smaller than the risky decks (decks A and B). Impulsive individuals tend to select the 'risky decks' as they offer greater short term reward (Burdick, Roy, & Raver, 2013). The participant's preference for risky or safe decks is calculated to provide a score of impulsivity, with a lower score indicating higher impulsivity (Burdick et al., 2013). There are five blocks of 20 trials and a score is calculated for each block with a minimum score of -20 and a maximum score of 20. These scores are summed to calculate an overall score. The task has been linked to real-world outcomes such as substance abuse and pathological gambling (Buelow & Suhr, 2009), and correlates well with self-reported measures of impulsivity (Franken et al., 2008). The IGT is one of the most widely used measures of decision making (Evens et al., 2016). Some concerns have been raised regarding practice effects, but as the current study is cross-sectional this is not a concern (Lin, Song, Chen, Lee, & Chiu, 2013). Age and gender matched normative data is available for the IGT (Bechara, 2007).

The Balloon Analogue Risk Task (BART): Was used as an objective measure of impulsivity. The participant is required to click a computer mouse to inflate a virtual balloon (Lejuez et al., 2002). Pumping the balloon earns money, but if the balloon bursts the money earned on that balloon is lost. The participant must make a trade-off between earning money by inflating the balloon, and collecting the money before the balloon explodes (Lejuez et al., 2002). The number of pumps required to burst the balloon is varied throughout the task (Lejuez et al., 2002). The average number of pumps on trials when the balloon did not explode is measured, with more pumps indicating greater risk taking behaviour (White, Lejuez, & de Wit, 2008). The BART has 30 trials and is scored by summing the average number of

pumps for the trials in which the balloon did not explode. The 30 trials are split into three blocks of 10, the higher the score for each block, the more impulsively the participant performed. The BART has correlated well with self-report measures of impulsivity, and has demonstrated predictive validity for real-world impulsive behaviours (such as smoking, gambling, and theft (Lejuez et al., 2002). The BART has a test-retest reliability of $r = .77$ (White et al., 2008). This task has been used previously in PD research to examine risk taking behaviour in those with ICDs (Rao et al., 2010)

Probabilistic Reward Task (PRT): Pizzagalli, Jahn, and O'Shea (2005) developed the PRT to create an objective behavioural measure of attraction to reward. The PRT is a signal-detection task, whereby the participant has to discriminate between two similar stimuli. Participants are instructed to try and gain as many points as possible by correctly discriminating between the two stimuli. They earn points by determining whether a face presented on a screen has a small (11.5mm) or a large mouth (13mm). A face appears on the screen for 500ms, followed by a small or large mouth for which is present for 100ms. The presentation of the long or short mouths is pseudorandomised, the same mouth is not shown more than three times in a row. The participant must identify whether the mouth was long or short by pressing the corresponding key on a keyboard. Participants complete three rounds of 100 trials with a break between each round. Only 40 correct answers are provided with a reward (five points) in each round. Prior to the commencement of the task, participants are informed that not all of their correct responses will be rewarded. They are not, however, made aware that the task has an asymmetrical reinforcement ratio. Throughout the task, one face is rewarded three times as often as the other (the more frequently rewarded face is counterbalanced between participants). This reinforcement ratio is used to create a response bias in the participant, and most people start to favour the more frequently rewarded face in their responses. The participant's response bias is recorded, with a bias towards the more frequently rewarded face indicating an attraction to reward/approach motivation. In contrast, a preference for the less frequently rewarded face, or a lack of a bias, indicates a more anhedonic pattern of behaviour (less attraction to reward). The PRT consists three blocks of 100 trials. For each block of trials, a response bias is calculated (ranging from -1 to 1), a positive response bias indicates a greater attraction to reward. The PRT had been used in numerous clinical populations

including people who have depression, bipolar disorder, and bulimia (Bogdan & Pizzagalli, 2006; Grob et al., 2012; Pizzagalli, Goetz, Ostacher, Iosifescu, & Perlis, 2008). The PRT has also been used in research investigating the influence of dopamine agonists on reward learning, demonstrating that a single dose of dopamine agonist medication can interfere with reward processing (Pizzagalli, Evins, et al., 2008).

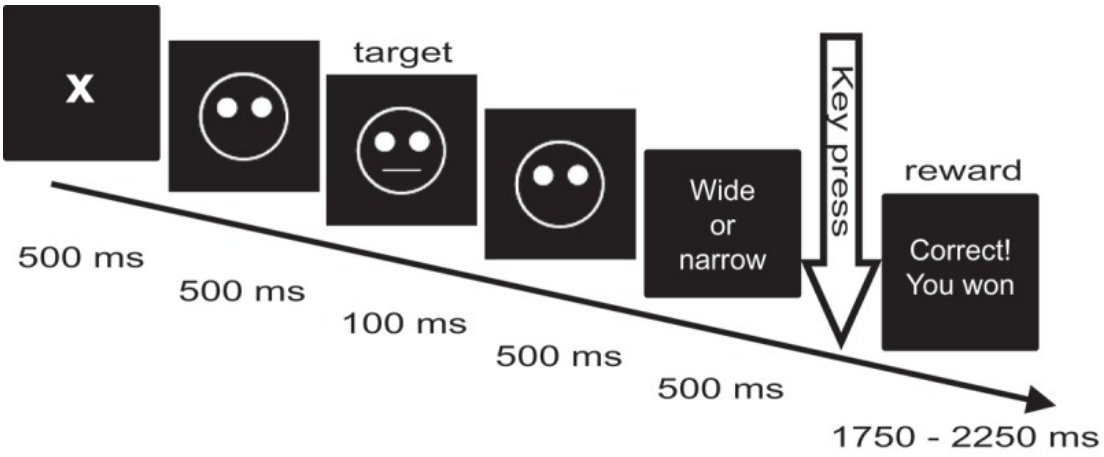

Figure 3.1 Depiction of the trial procedure in the Probabilistic Reward Task. Taken from Eskelund, Karstoft, and Andersen (2018).

Table 3.2 Summary of measures

Measure	Outcome(s) assessed	Scoring
Demographic questionnaire	Age, relationship status, occupation (past or present), age of PD onset, familial history of PD, medication use, and co-morbid medical issues	N/A
Telephone Interview for Cognitive Status-30 (TISC-30)	Screens for the presence of dementia	Min 0, Max 30 Cut-off score: 18
Unified Parkinson's Disease Rating Scale -III (UPDRS-III)	Assesses the severity/presence of PD motor symptoms	Min: 0 Max: 104
The Behavioural Inhibition System/Behavioural Activation System Scale (BIS/BAS)	Operationalises the behavioural activation and inhibition systems. The measure has four subscales, BAS Drive, BAS Fun seeking, BAD reward responsiveness, and the Behavioural Inhibition Scale	BAS D: Min 4, Max 16 BAS FF: Min 4, Max 16 BAS RR: Min 5, Max 20 BIS: Min 7, Max 28
Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease–Rating Scale (QUIP-RS)	Screens for the presence of commonly reported Impulse Control Disorders in PD	Gambling: Min 0, Max 16 Cut-off ≥6 Buying: Min 0, Max 16 Cut-off ≥8 Sex: Min 0, Max 16 Cut-off ≥8 Eating: Min 0, Max 16 Cut-off ≥7 Hobbyism-Punding: Min 0, Max 16 Cut-off ≥7
Screening for Risky Behaviours Battery (SERB)	Battery of measures designed to screen for engagement in impulsive behaviours	Min 0, Max 70 See Appendix F for detailed scoring information.

Beck Cognitive Insight Scale (BCIS)	Assesses a person's level of insight. Comprised two subscales (self-reflectiveness and self-certainty) that are used to calculate a composite score.	Self-reflectiveness: Min 0, Max 27 Self-certainty: Min 0, Max 18 Composite Score (self-reflectiveness minus self-certainty): Min -18, Max 27
The Iowa Gambling Task (IGT)	Impulsive/risk taking behaviours	Min -100, Max 100
The Balloon Analogue Risk Task (BART)	Impulsive/risk taking behaviours	Min 30, Max N/A (varies due to random nature of the task)
Probabilistic Reward Task (PRT)	Reward responsiveness	Min -1, Max 1

3.7 Procedure

Potential participants who responded to the advertising were contacted by phone to confirm that they met the inclusion criteria. The TICS-30 was administered in this initial phone call to determine if a potential participant had symptoms of dementia (total score < 18), however as no one met the criteria for dementia no participants excluded on this basis. Participants were also asked if they would be able to nominate an informant (someone who knew them well) to take part in the research project. Eligible participants who wished to take part in the research booked a testing appointment over the phone. If participants were willing and able to come to the NeuroLab at Curtin University, an appointment was made for them to attend the laboratory. If they were not able to come to Curtin University, an appointment was made to conduct the testing at their home. At least two weeks prior to their testing appointment, a package was sent to the participant's address via post. The package contained an information sheet (Appendix H), a map (for participants attending Curtin University), and a questionnaire booklet containing the questionnaires listed in the methods section (Appendices A, B, D, E, F, and G). The pack also contained an envelope with the materials for the nominated informant, including an information

sheet (Appendix I), consent form (Appendix J), questionnaire booklet (appendix K), and a reply paid envelope for return to the researcher. Upon consenting, nominated informants were asked to complete the questionnaire booklet. The researchers' (Leon Booth and his supervisors) contact details were provided to the nominated informants, so that they could ask any questions they had regarding the research. Participants were asked to complete their questionnaire booklet prior to the testing appointment, and to bring the completed questionnaires to their appointment. The nominated informants could provide their completed questionnaires to the participant in a sealed envelope (for the participants to bring to their testing appointment). Alternatively, the nominated informant could send their questionnaires to the lead researcher at Curtin University using the reply paid envelope provided.

All participants attended the testing appointment during the 'on' phase of their medication. At the testing appointment, the lead researcher (Leon Booth) went through the information sheet with the participant and answered any questions that the participant had. A consent form (Appendix L) was signed prior to testing. The lead researcher conducted all of the testing to ensure consistency in data collection. The UPDRS-III was administered first, to assess the severity of the participant's motor symptoms. A separate researcher who was trained in the administration of the UPDRS-III was present for a quarter of the assessments to double score the UPDRS-III. The administration of the three behavioural tasks (IGT, BART, and PRT) was randomised using a random number generator. After the first of the three behavioural tasks was administered, a ten minute rest-break was taken. Participants were also provided with opportunities to take breaks throughout the testing session. After testing was completed, the participant was be debriefed and the researcher answered any questions that they had. Given the nature of the study, a debriefing sheet (Appendix M) was provided to participants with the contact details of various agencies that assist with problematic impulsive behaviours. The debriefing sheet also provided the contact details of the lead researcher and project supervisors. After the testing session, the lead researcher entered all the data into an SPSS database.

Chapter 4 Study 1: Exploring whether self-reported impulsivity as measured by the QUIP-RS and the BIS/BAS scale is associated with risky behaviours in PD

4.1 Introduction

Problematic impulsive behaviours increase the hardship associated with PD, for both the person with PD and their friends/family (Leroi et al., 2012; Phu et al., 2014). Impulsive behaviours in PD are thought to be under-reported, and consequently, these behaviours could be left untreated (Weintraub, Siderowf, & Potenza, 2006). Under-diagnosis could be attributed to people with PD not disclosing their impulsive behaviours as they are embarrassed by them, or they might lack the insight to recognise that they have a problem with impulsive behaviours (Baumann-Vogel et al., 2015; Weintraub et al., 2015). Screening for these behaviours is not common in clinical practice, which may further contribute to the under-diagnosis of impulsivity issues (Weintraub et al., 2015). These issues can be compounded by the limitations of assessment instruments that have been developed for the identification of impulsive behaviours in PD (G. Zhang et al., 2014). Effective impulsivity measures can assist clinicians to treat people affected by these behaviours (Mestre et al., 2013; Ramirez-Zamora et al., 2016). Valid assessments of impulsivity are crucial for enabling future research that aims to further the understanding of this issue for people with PD (Probst et al., 2014).

Weintraub et al. (2012) developed the Questionnaire for Impulsive-Compulsive Disorder in Parkinson's Disease-Rating Scale (QUIP-RS) to screen for six impulsive behaviours that are commonly seen in PD, including four Impulse Control Disorders (ICDs) which are set out in the DSM-5. The QUIP-RS builds upon its predecessor (the QUIP) by providing a rating-scale response format to assess the severity of the person's impulsive behaviours. In this way, the measure assesses both the presence and severity of impulsive behaviours in people with PD (Weintraub et al., 2012). Cut-off scores are used to determine whether a particular impulsive behaviour is a clinically significant. Additionally, the QUIP-RS provides a total score as an indication of overall impulsivity. The QUIP-RS is considered to be one of the most comprehensive and well validated measures for the assessment of impulsive

behaviours in PD (Evans et al., 2019; Pablo Martinez-Martin et al., 2016). Leeman, Billingsley, and Potenza (2012) reviewed prevention and management strategies for ICDs in PD, and recommended that the QUIP-RS be used to screen for ICDs in clinical practice. According to Leeman et al. (2012), the QUIP-RS is a quick, easily administered screening measure that can inform clinicians about a PD client's engagement in the six impulsive behaviours it examines.

Although the QUIP-RS is arguably the most comprehensive measure of problematic impulsive behaviours in PD, it is a relatively new measure and research evaluating it is somewhat scarce. As discussed in chapter two, Probst et al. (2014) examined the validity of the QUIP-RS in a German population. They suggested that while the QUIP-RS is a valid screening measure, it is vulnerable to a high rate of false positives (indicative of low specificity). Issues regarding the specificity of the QUIP-RS were also noted in the original article by Weintraub et al. (2012), and subsequent papers reviewing the measurement of impulsive behaviours in PD (Pablo Martinez-Martin et al., 2016). Regardless, the QUIP-RS has been widely used in the PD impulsivity literature (Ricciardi et al., 2016), and 165 articles have so far cited the original paper by Weintraub et al. (2012). It is important to further explore the QUIP-RS to inform future research and clinical practice.

Impulsive behaviours in PD go beyond the behaviours that are examined in the QUIP-RS. Case-study research has reported impulsive behaviours such as dangerous driving, smoking behaviours, and reckless generosity in PD (Avanzi et al., 2008; Bienfait et al., 2010; O'Sullivan et al., 2010). While these are only case studies, they may indicate that the scope of impulsive behaviours in PD goes beyond the behaviours that are commonly examined in the literature and by the QUIP-RS. Enticott and Ogloff (2006) stated that a multitude of different behaviours can manifest from impulsivity. In line with this, impulsivity in the general population has been linked to a myriad of problematic behaviours including violence, substance abuse, risk taking, and social irresponsibility (Sharma et al., 2013). A comprehensive assessment of impulsivity in PD should, therefore, consider a range of problematic impulsive behaviours. In the non-PD literature, such behaviours have been shown to significantly impact on people's lives and are a leading cause of death in Western society (Braddock et al., 2011). Due to the QUIP-RS' focus on ICDs, it is reasonable to suggest that the measure may not successfully capture general impulsive behaviours in PD. This would mean that some impulsive people risk being

overlooked by the QUIP-RS, and the measure may underestimate the actual extent of impulsive issues in PD. Furthermore, if clinicians use the QUIP-RS to screen for impulsive behaviours, people with problematic impulsive behaviours that are not covered by the QUIP-RS risk missing out on treatment.

To assess a diverse range of impulsive behaviours in PD, the Screening for Risky Behaviours Battery (SERB) was compiled. The SERB was assembled specifically for the present research project to assess impulsive behaviours identified in non-PD impulsivity literature. The SERB comprises five previously established measures of risky behaviours and assesses seven areas of impulsive behaviours: Alcohol consumption, tobacco consumption, drug consumption, gambling, violence, general risky behaviours, and socially inappropriate comments. The focus of the SERB is to screen for the frequency of risky behaviours, rather than requiring the participant to make a subjective judgement about whether the behaviour is problematic or not. Previous research has successfully used multiple measures of risky behaviours in this manner (Lejuez et al., 2002; Sharma et al., 2013; Upton, Bishara, Ahn, & Stout, 2011). Further information about the development of the SERB can be found in chapter three (method chapter).

An alternative means of measuring impulsivity in PD may be to focus on general impulsive tendencies, rather than specific behaviours. Measurement using this strategy would not be dependent on people displaying specific impulsive behaviours to be identified as impulsive (as is the case with the QUIP-RS). In chapter two, it was proposed that a commonality exists across multiple domains of impulsivity research, whereby impulsivity can be thought of as an over-attraction to reward and an under sensitivity to punishment (Bechara, 2005; Cross et al., 2011; J. A. Gray, 1987). The BIS/BAS scale developed by Carver and White (1994) was developed to capture these aspects of impulsivity. Based on Gray's (1987) biological basis of impulsivity, the BIS/BAS scale operationalises the BIS system (fear of punishment) and the BAS system (attraction to reward). Using this more general measure of impulsivity may be useful for PD research to capture a wider scope of behaviours. The BIS/BAS scale has been used successfully in previous PD research to examine responsiveness to reward and punishment (Boksem et al., 2006; Jordan et al., 2013).

The present study is an exploratory study to examine the relationships between the QUIP-RS (ICD measure), the BIS/BAS scale (impulsivity measure), and

the frequency of impulsive behaviours (as measured by the SERB). Exploring the relationships between these measures will help to determine whether measures such as the QUIP-RS are limited by their focus on specific impulsive behaviours. Moreover, this approach will help to determine whether more general measures (such as the BIS/BAS scale) provide additional information (to that of specific measures such as the QUIP-RS) about impulsivity in PD. For any measure to be an ecologically valid measure of impulsivity, they should relate to engagement in the range of impulsive behaviours that are present in PD. It should be noted that the QUIP-RS is not designed to assess the wider range of behaviours examined by the SERB. If the SERB identifies that people with PD are engaging in a broader range of risky behaviours than those examined by the QUIP-RS, it will be useful to know whether the responses on QUIP-RS relate to reporting in the SERB. This will inform research and clinicians about the use of the QUIP-RS in clinical practice, and the possible shortcomings of focusing upon specific impulsive behaviours in the PD literature.

4.2 Hypotheses

1. Scores on the BIS/BAS scale will predict a significant amount of variance in the SERB overall score, such that the BAS subscales will be positively associated with the SERB and the BIS score will be negatively associated with the SERB. This would indicate that engagement in impulsive behaviours is related to an increased attraction to reward and a decreased sensitivity to punishment.
2. The QUIP-RS total score will demonstrate a significant positive association with the SERB. This would indicate that people with ICDs in PD engage in impulsive behaviours beyond the six ICDs covered by the QUIP-RS (i.e., their heightened impulsivity manifests as multiple comorbid problematic impulsive behaviours).
3. The QUIP-RS score will not predict a significant amount of variance on the SERB overall score, beyond the variance already accounted for by the BIS/BAS scale. Being a more general measure of impulsivity, it is expected that the BIS/BAS scale will better predict engagement in the behaviours assessed by the SERB that the ICD focussed QUIP-RS.

4.3 Analyses

The data were analysed using SPSS version 24, assumption tests were conducted prior to analyses A series of bivariate pearson correlations were performed to test hypotheses one and two. To test hypothesis three, a hierarchical multiple regression analysis was conducted. The predictor variables entered into the model were as follows: Age, gender, current dopamine agonist dose, current L-Dopa equivalent dose, UPDRS III score (step one), BAS Drive, BAS Fun Seeking, BAS Reward Responsiveness, BIS (step two), and the QUIP-RS Total score (step three). Age gender, dopamine agonist dose, levodopa equivalent dose, and UPDRS III scores were entered at step one as control variables, as these factors have previously been shown to affect impulsivity (Cross et al., 2011; Weintraub et al., 2010). The criterion variable was the overall score for the SERB.

4.4 Results

Demographic data for the participants is provided in chapter three. The assumption of normality was not violated for BAS Drive, BAS Funseeking, Bas Reward responsiveness, BIS, and SERB Total score. The QUIP-RS does appear to be approximately normally distributed, but the distribution of scores is mildly positively skewed. The subsequent analyses can tolerate such mild departures from normality. As such, the distribution of the QUIP-RS scores was not considered to be an issue that required intervention. Visual inspections of scatterplots between the variables also indicated that the assumptions of linearity and homoscedasticity were met.

The descriptive statistics for the scales are provided in Table 4.1. The results of the bi-variate correlations revealed that two of the BIS/BAS subscales demonstrated significant positive relationships with the SERB (BAS Drive and BAS Funseeking). Additionally, the QUIP-RS total score was also significantly positively associated with the SERB. The results are displayed in Table 4.2.

Table 4.1 Means, standard deviations, and range of scores for each assessment of impulsivity

Task	M(SD)	Range (Min – Max)
QUIP-RS	21.6 (15.4)	0 - 81
SERB	7.6 (4.4)	0.5 - 19.2
BAS Drive	2.4 (.7)	1 - 4
BAS Fun Seeking	2.6 (.7)	1.25 - 4
BAS Reward Responsiveness	3.1 (.6)	1.4 - 4
BIS	2.8 (.5)	1.7 - 4

Table 4.2 Pearson bi-variate correlations between the self-reported impulsivity (BIS/BAS and QUIP-RS) and the SERB overall score

	M (SD)	1	2	3	4	5	6
1. SERB	7.6 (4.4)	-					
2. QUIP-RS	21.6 (15.4)	.56**	-				
3. BAS Drive	2.4 (.71)	.41**	.35**	-			
4. BAS Fun	2.6 (.66)	.40**	.44**	.67**	-		
5. BAS Reward	3.1 (.58)	.25*	.32**	.67**	.60**	-	
6. BIS	2.8 (.53)	.09	.19	.29*	.22	.47**	-

Note; SERB = SERB total score, QUIP-RS = QUIP-RS total score, BAS Fun = BAS Funseeking, and BAS Reward = BAS reward responsiveness.
**p < .05 (two tailed) **p < .01 (two tailed)*

The results of the hierarchical regression demonstrated that the QUIP-RS total score and age were the only predictors in the model that accounted for a significant amount of unique variance in the SERB total score at step three. The results are summarised in Table 4.3. The model entered at step one predicted a significant amount of variance in the SERB overall score (F (5, 60) = 4.79, p = <.001, adjusted R^2 = .29,). The model entered at step two did predict a significant amount of variance in the SERB total score (F (9, 56) = 3.98, p = <.001, adjusted R^2 = .39), however none of the BIS/BAS subscales uniquely accounted for a significant amount of variance. At step three the QUIP-RS total score was added to the regression model and accounted for an additional 10% of variance in the SERB overall score. In combination, all of the predictor variables explained 49% of variance in the SERB overall score, F (10, 55) = 5.27, p < .001, adjusted R^2 = .49.

Table 4.3 Unstandardized (B) and standardised (β) regression coefficients for predictors of SERB overall score using a hierarchical regression analysis.

	B [95% CI]	B	p-value
Step 1			
Age	-.18 [-.30, -.07]	-.38**	.002
Gender (Female)	-3.09 [-5.06, -1.11]	-.36**	.003
Current DA dose	-.18 [-.66, .31]	-.09	.467
L-Dopa equivalent dose	<.001 [<.001, <.001]	.06	.659
UPDRS III	.05 [-.03, .13]	.14	.245
Step 2			
Age	-.16 [-.28, -.05]	-.34**	.006
Gender (Female)	-2.39 [-4.35, -.43]	-.28*	.018
Current DA dose	-.21 [-.72, .29]	-.11	.399
L-Dopa equivalent dose	<.001 [<.001, <.001]	-.01	.957
UPDRS III	.01 [-.07, .10]	.04	.761
BAS Drive	1.25 [-.88, 3.37]	.20	.244
BAS Fun Seeking	1.58 [-.41, 3.56]	.24	.117
BAS Reward Responsiveness	-.46 [-3.00, 2.08]	-.06	.719
BIS	-.43 [-2.54, 1.69]	-.05	.688
Step 3			
Age	-.13 [-.24, -.03]	-.28*	.015
Gender (Female)	-1.66 [-3.53, .21]	-.19	.080
Current DA dose	-.20 [-.66, .27]	-.11	.395
L-Dopa equivalent dose	<.001 [<.001, <.001]	-.03	.759
UPDRS III	.00 [-.08, .08]	.00	.994
BAS Drive	1.29 [-.67, 3.25]	.21	.194
BAS Fun Seeking	.78 [-1.11, 2.68]	.12	.411
BAS Reward Responsiveness	-.56 [-2.90, 1.79]	-.07	.637
BIS	-.67 [-2.63, 1.29]	-.08	.494
QUIP-RS	.11 [.04, .17]	.37**	.002

Note. CI = confidence Interval. β coefficients are standardised in terms of units of measurement.
**p < .05 (two tailed) **p < .01 (two tailed) ***p < .001 (two tailed)*

Given it was not expected that the QUIP-RS would predict a significant amount of variance beyond the BIS/BAS scale, further analyses were conducted. A series of bivariate correlations between the QUIP-RS and the behaviours assessed by the SERB explored the specific nature of the relationship between the two measures. The results of the bivariate correlations are summarised in Table 4.4. Note that the relationship with tobacco consumption could not be determined, as no participants indicated that they currently smoked.

Table 4.4 Correlations between behaviours assessed by the SERB and the QUIP-RS total score

	1	2	3	4	5	6	7
1. QUIP-RS	-						
2. Alcohol	.26*	-					
3. Drug Use	.47**	-.01	-				
4. Gambling	.41**	.30*	.33**	-			
5. Aggression	.30*	.12	.16	.10	-		
6. Risky Behaviours	.45**	.31*	.32*	.63**	.25*	-	
7. Inappropriate comments	.36**	.24*	.08	.27*	.29*	.44**	-

**p < .05 (two tailed) **p < .01 (two tailed)*

4.5 Discussion

Hypothesis one was partially supported, two BAS subscales (BAS Drive and BAS Funseeking) demonstrated a moderate positive relationship with the SERB. However, the BAS Reward Responsiveness was only weakly associated with the SERB and the BIS subscale did not relate to scores on the SERB. This suggests that the behavioural activation system (attraction to reward) proposed by J. A. Gray

(1987) relates to engagement in impulsive behaviours in PD, whereas a reduction in sensitivity to punishment does not.

There was support for hypothesis two, in that the QUIP-RS demonstrated a strong positive association with the SERB overall score. This indicates that engagement in the six behaviours assessed by the QUIP-RS relates to engagement in the behaviours assessed by the SERB. The results of the hierarchical regression do not support hypothesis three. As would be expected, younger age and male gender were both associated with engagement in impulsive behaviours (Cross et al., 2011). However, contrary to predictions, the QUIP-RS total score accounted for a significant amount of variance in the SERB overall score. The BIS/BAS scale did not account for a significant amount of variance in the SERB, beyond that which was already accounted for by the QUIP-RS. Therefore, scores on the QUIP-RS appear to be a better indication of participation in general impulsive behaviours in PD than the BIS/BAS scale.

4.5.1 Relationship between the QUIP-RS and SERB.

It was predicted that the QUIP-RS would have a poor relationship with the SERB, as the QUIP-RS targets specific impulsive behaviours and the SERB measures a broader range. Contrary to expectations, the QUIP-RS demonstrated a significant positive relationship with the SERB. These findings are novel, as they suggest that the QUIP-RS can predict engagement in impulsive behaviours beyond those it directly screens for. Furthermore, as Table 4.4 illustrates, the QUIP-RS demonstrated significant positive relationships with all six of the general risky behaviours examined by the SERB. Given these relationships were unforeseen and not commonly explored in the PD literature, it is important to investigate them further and consider the practical implications of these findings.

4.5.2 Alcohol consumption

The QUIP-RS does not ask about alcohol consumption. However, the QUIP-RS total score demonstrated a small-moderate positive relationship with alcohol consumption as measured by the SERB. This indicates that people with PD who are assessed as more impulsive on the QUIP-RS are more likely to report consuming higher quantities of alcohol. Impulsivity has been associated with increased alcohol consumption in adolescents (Stautz & Cooper, 2013), but only a handful of studies

have investigated factors associated with alcohol consumption in older adults (the mean age for PD participants in the present study was 66 years old; Moos, Schutte, Brennan, & Moos, 2009). PD research examining the relationship between impulsivity and alcohol consumption has yielded mixed results. Two large cross sectional studies by Voon, Sohr, et al. (2011) and Weintraub et al. (2010) compared PD participants identified as having an ICD to PD participants without an ICD. The results of both studies revealed that there was no significant difference between the two groups (with, without ICD) in terms of alcohol consumption. Such findings are at odds with the present findings, as they suggest that impulsivity in PD is not associated with higher alcohol consumption. Both Voon, Sohr, et al. (2011) and Weintraub et al. (2010) used the Minnesota Impulsive Disorders Interview to identify whether their participants had an ICD, which may limit the validity of their results. This measure has several limitations, such as only screening for ICDs listed in the DSM III-R, (several of which have since been superseded) and not screening for ICDs more specific to PD like punding behaviours (Mestre et al., 2013).

In line with the present findings, studies by Voon, Thomsen, Miyasaki, de Souza, et al. (2007) and Dodd et al. (2005) found that PD participants with pathological gambling disorders (an ICD) had a higher incidence of alcohol use disorders compared to those without pathological gambling disorders. These results suggest that pathological gambling, which the QUIP-RS assesses, has previously been linked to higher alcohol consumption. Evans, Lawrence, et al. (2006) examined the relationship between impulsive sensation seeking and alcohol consumption in both PD and control participants. Consistent with the present findings, the results revealed a significant moderate positive relationship between impulsivity and alcohol consumption. This was across all participants in the study (control and PD), unfortunately the relationship for the PD participants alone was not reported. Fan, Ding, Ma, and Chan (2009) assessed the presence of ICDs in 312 people with PD and confirmed the diagnoses with a clinical assessment conducted by a neurologist. A total of 11 participants were identified as having an ICD, and those with an ICD were significantly more likely to consume alcohol than those without.

Overall, the results regarding the relationship between impulsivity and alcohol intake in PD are mixed. Two large cross-sectional studies found no relationship between the two, while several (albeit smaller) studies have suggested that higher impulsivity may be associated with increased alcohol intake. The current

findings do suggest that a weak to moderate association exists between impulsivity and alcohol consumption in PD.

The present relationship between impulsivity and alcohol consumption in PD does fit with research investigating alcohol use disorders in the general population. Such research has revealed that impulsive individuals are at a higher risk of developing alcohol use disorders, and are more likely to consume higher quantities of alcohol than less impulsive individuals (Dick et al., 2010). Impulsive individuals are thought to be more likely to consume alcohol due to impaired decision making resulting from deficits in frontal areas of the brain (Crews & Boettiger, 2009). Alcohol use can compound this problem by inducing changes in the brain which make a person more impulsive, specifically by impacting frontal areas and causing functional changes to limbic areas (Bühler & Mann, 2011; Crews & Boettiger, 2009). Similar frontal and limbic abnormalities are also seen in PD, especially in people with impulsivity issues (Cossu et al., 2018; O'Callaghan et al., 2013). This suggests that changes in the brain that make people with PD more likely to be impulsive, may also make them more likely to consume higher quantities of alcohol, which fits with the present results.

4.5.3 Drug consumption

Scores on the QUIP-RS were moderately positively correlated with self-reported drug consumption on the SERB, despite the QUIP-RS not specifically targeting drug consumption. Additional research investigating recreational drug use in PD is limited. Mursaleen and Stamford (2016) investigated whether the use of cannabis differed between people with PD based on the dopaminergic medications they used. The results revealed that 23.1% of PD participants on dopamine agonists reported using cannabis, which was twice as many as those taking levodopa alone. The use of dopamine agonists could make a person more liable to taking recreational drugs, as dopamine agonists are thought to make people with PD more impulsive (Claassen et al., 2017). Therefore, while Mursaleen and Stamford (2016) did not explicitly examine impulsivity, their results suggest that dopamine agonists may make some people with PD more impulsive, and therefore more likely to engage in illicit drug consumption. Mursaleen and Stamford (2016) concluded that the relatively high use of cannabis among their participants was likely due to PD-related changes in the brain that increase reward seeking behaviours and predispose people

with PD to abuse both illicit and non-illicit drugs. The current results go some way to supporting this, as drug use was more frequent in the PD participants who reported being more impulsive on the QUIP-RS. It is worth noting that the consumption of cannabis is seen by some with PD as having a therapeutic benefit (Mursaleen & Stamford, 2016), and in this circumstance it might not be appropriate to consider cannabis consumption as a risky or impulsive behaviour.

A link between illicit drug consumption and impulsivity in PD was also reported by Klos, Bower, Josephs, Matsumoto, and Ahlskog (2005). The authors reviewed 15 case studies of PD participants who had developed hyper sexuality. They noted that a number of the participants had also increased their use of recreational drugs alongside the onset of their hypersexuality, but this was not explored any further. Nonetheless, this finding lends support to the association between ICDs and recreational drug use in PD. It is possible that Klos et al. (2005) did not further explore the recreational drug taking noted in their case studies because of the sensitive nature of illicit drug consumption. Mursaleen and Stamford (2016) acknowledged that in their own survey, the response rates to the questions concerning cannabis were comparatively low - suggesting that people might not be comfortable answering these questions. Moreover, participants in the Mursaleen and Stamford (2016) study reported that a major barrier to recreational drug use was the illegal status of these drugs. This concern about the illegal status of recreational drugs may also make people less likely to disclose using them. In the data collection for this thesis, two of the four people who revealed they used cannabis only did so during the face to face testing session (after some rapport between the researcher and the participant had been built). Overall, the sensitivity of the topic may account for the lack of research that has investigated the use of illicit drugs in PD, and could mean that these behaviours are under-reported in PD research and clinical practice.

Like alcohol consumption, the relationship between the use of illicit drugs and impulsivity is likely to be bi-directional (Grant & Chamberlain, 2014). Being impulsive makes a person more likely to partake in drug use (Crews & Boettiger, 2009), and drug use is likely to make a person more impulsive by impacting frontal areas of the brain (Grant & Chamberlain, 2014). As the consumption of these drugs is detrimental to a person's health and can further damage areas of the brain already impacted by PD, it is important that research future explores how impulsivity in PD

may contribute to recreational drug use and how recreational drug use could affect people with PD (Grant & Chamberlain, 2014).

4.5.4 Aggression

In the present sample, higher scores of aggression/violence on the SERB were associated with higher scores on the QUIP-RS. The brief aggression questionnaire developed by Webster et al. (2014) was used to assess aggression, and has previously been shown to predict actual engagement in aggressive/violent behaviours (Webster et al., 2015). Research examining aggression in PD is limited (Bruno, Mancini, Ghoche, Arshinoff, & Miyasaki, 2016). Several reviews of neuropsychiatric symptoms in PD note issues such as impulsive behaviours, depression, cognitive impairment, and dementia, but make no mention of aggression/violence in PD (Aarsland & Kramberger, 2015; Mueller et al., 2018). However, several studies have used the Neuropsychiatric Inventory in PD, which includes an item that screens for clinically significant agitation/aggression. These studies have generally found that 1-2% of people with PD exhibit significant levels of aggression (Aarsland et al., 2009; Kulisevsky et al., 2008). Additionally, heightened aggression has been noted in several PD case studies. Giovannoni, O'Sullivan, Turner, Manson, and Lees (2000) described 15 case studies of people with PD and multiple ICDs (dopamine dysregulation syndrome coupled with hypersexuality). They observed that these participants experienced heightened levels of aggression, which in some situations had required police intervention. The participants were noted to become aggressive if their demands for more medication were not met, and they also engaged in aggressive sexual advances. Another case study by Romana et al. (2004) also observed violent behaviour in several people with PD and dopamine dysregulation syndrome.

A larger study by Bruno et al. (2016) asked the caregivers of 52 advanced-stage PD participants if the person with PD displayed physical or sexual aggression. The responses from the caregivers revealed a high prevalence of physical aggression and sexual aggression (65% and 35%, respectively). Another PD study by Ahearn, McDonald, Barraclough, and Leroi (2012) found a modest positive correlation between aggression and self-reported impulsivity (r = .29). However, this was not the focus of their study and was not explored in detail. Together, these results suggest that aggression is related to impulsivity in Parkinson’s, especially for people

with PD and ICDs. As the QUIP-RS screens for the presence of impulsivity issues and ICDs, it stands to reason that it was positively associated with higher aggression scores in our sample.

Although the present results suggest that aggression in PD might be related to increased impulsivity, the mechanism underlying increased aggression in PD remains poorly understood. A case study by Sensi et al. (2004) described a person with PD who exhibited increased aggression following deep brain stimulation treatment. The patient's aggression was only present when the deep brain stimulation was active (Sensi et al., 2004). Sensi et al. (2004) proposed that the stimulation from the electrode might unintentionally be stimulating areas in the nearby limbic system, and that this limbic activation elicited the impulsive outbursts and aggressive behaviour observed. Aggression in PD has also been related to cortical thinning in temporal and occipital areas, suggesting that atrophy in these areas is linked to aggression in PD (Ye et al., 2018).

While the link between impulsivity and aggression in PD has not been explored in depth, impulsivity has been linked to aggression in other clinical populations, such as people with traumatic brain injury, ADHD, and schizophrenia (Carmona et al., 2009; Nanda et al., 2016; Wood & Thomas, 2013). As these impulsive populations demonstrate increased aggression, it is plausible that impulsivity can drive increased aggression in PD. Despite aggression in PD being reported to have a significant impact upon both people with PD and their friends/family (Bruno et al., 2016), research in the area is still very limited. At present, only a very tentative link can be made between impulsivity and aggression in PD, with the results of our research adding further evidence for this relationship.

4.5.5 General risky behaviours

To identify the engagement in general risky behaviours in PD, we used questions from the Youth Risk Behaviour Surveillance System (Centers for Disease Control and Prevention, 2015). Previous research has employed the same questions for similar purposes (Braddock et al., 2011; Lejuez, Aklin, Zvolensky, et al., 2003). The QUIP-RS demonstrated a modest to strong positive relationship with these behaviours. This demonstrates that people with higher impulsivity as measured by the QUIP-RS are more likely to engage in general risky behaviours as measured by the SERB. General risky behaviours are a significant contributor to premature death

in the developed world (Braddock et al., 2011), which highlights the need for future research to further investigate these behaviours in PD.

4.5.6 Inappropriate comments

Based on anecdotal evidence provided by PD specialist nurses in the Perth community, the present study examined whether more impulsive PD participants were more likely to make inappropriate comments. The SERB examined whether people made inappropriate comments by asking questions like have you "Made an inappropriate remark or comment in conversation" or "Had someone mention that something you have said is inappropriate". The results revealed that the participants who self-reported being more impulsive also reported making more inappropriate comments. Research is increasingly recognising impaired social functioning as a facet of numerous neurodegenerative disorders, including more frequent socially inappropriate behaviours and comments (Desmarais, Lanctôt, Masellis, Black, & Herrmann, 2018). While the research specific to PD is limited, case studies of people with PD and hypersexuality (an ICD) have reported people making frequent inappropriate sexual comments (Mania, Evcimen, & Mathews, 2006). The current finding demonstrates a potential link between heightened impulsivity and inappropriate comments.

Another explanation for the observed correlation between impulsivity and inappropriate comments is that theory of mind is impaired in PD. Theory of mind is the ability to understand another person's mental state, and it is negatively affected if someone has compromised frontal/executive functioning (Bora, 2017). Impaired theory of mind makes it difficult for people with PD to understand social situations and socialise effectively (Bora, Walterfang, & Velakoulis, 2015). It is thought that reduced theory of mind could contribute to people with PD making inappropriate comments in social situations (Yu & Wu, 2013). It is possible that when people with PD demonstrate frontal atrophy, reduced theory of mind leads people to be more impulsive and less discerning in social settings (Bora et al., 2015). However, this link has not yet been explored in the literature. A recent meta-analysis of theory of mind in PD did not consider impulsivity (Bora et al., 2015). Likewise, literature examining inappropriate comments/outbursts in PD is limited. The present study highlights that these behaviours are present in PD and could be linked to increased impulsivity. Given this link has also been observed in other impulsive populations, such as people

with ADHD and schizophrenia, it warrants further investigation in PD (Bunford et al., 2015; Nanda et al., 2016).

4.5.7 QUIP-RS and the SERB

Overall, it is evident that the impulsive behaviours assessed by the SERB have not been extensively researched in PD, despite these types of behaviours having been linked to impulsivity in the general population (Sharma et al., 2013). The current findings demonstrate that behaviours such as alcohol/drug consumption, aggression, and other impulsive behaviours are present in PD. Several studies have noted that these behaviours have a significant detrimental impact on people with PD and people in the general population (Bruno et al., 2016; Mursaleen & Stamford, 2016; Squeglia, Boissoneault, Van Skike, Nixon, & Matthews, 2014). Therefore, these behaviours are likely to contribute to the burden that impulsive behaviours have on people with PD and their peers. To fully appreciate the true scope of the impulsivity problem in PD, research needs to examine how problematic impulsive behaviours besides the commonly identified ICDs are affecting people.

The relationship between the QUIP-RS and the impulsive behaviours in the SERB also has clinical significance. Leeman et al. (2012) recommended that the QUIP-RS be used as a screening measure in clinical practice. Based on the current findings, if a person engages in the behaviours assessed by the QUIP-RS then it is possible that they might be engaging in other risky behaviours. Therefore, if a client scores highly on the QUIP-RS, clinicians should then explore whether their client is engaging in other impulsive behaviours, such as those examined in the present study. Only focussing on treating the ICDs screened for by the QUIP-RS risks overlooking other impulsive behaviours that a person with PD could be engaging in.

4.5.8 QUIP-RS and the BIS/BAS scale

Chapter two suggested that the best way to conceptualise impulsivity is as an over attraction to reward and an under sensitivity to punishment. Based on this, it was hypothesised that the BIS/BAS scale would demonstrate the strongest relationship with the engagement in impulsive behaviours as measure by the SERB. However, in the hierarchical regression model, the QUIP-RS was the only variable that predicted a significant amount of variance in the SERB (see Table 4.3). These results may suggest that the BIS/BAS scale is not a useful measure of impulsivity in

PD, and that impulsivity in those with PD is not an over attraction to reward and an under sensitivity to punishment. To further explore these unexpected results and the use of the BIS/BAS scale in PD, the relationship between the BIS/BAS and the QUIP-RS was examined.

The results revealed that the three subscales of the BAS all demonstrated moderate positive correlations with the QUIP-RS total score (see Table 4.2). This indicates that attraction to reward drives engagement in ICDs in PD. Conversely, the BIS score did not relate to the QUIP-RS, suggesting that a greater fear of punishment does not decrease engagement in these behaviours. This is contrary to the expectation that a fear of negative consequences should inhibit impulsive behaviours (Bechara, 2005; Cross et al., 2011; Macphee & Carson, 2013). This finding could indicate that fear of punishment is not a major component of ICDs in PD. Potentially different aspects of impulsivity that are explored in the literature such as disinhibition would better capture the nature of ICDs in PD (Antonelli, Ray, & Strafella, 2011; Manza, Amandola, Tatineni, Li, & Leung, 2017).

4.5.9 Attraction to reward and ICDs

Impulsive behaviours like those in the QUIP-RS can be referred to as hedonistic/pleasurable behaviours, as they would be regarded by most people as being rewarding (Macphee & Carson, 2013). This might explain why people with PD can be attracted to these behaviours, and why in the present sample the participants with a higher attraction to reward were more likely to engage in these behaviours. An excessive attraction to reward might, therefore, manifest as excessive engagement in the behaviours assessed by the QUIP-RS. Knowing that the attraction to reward, rather than the fear of punishment, is associated with impulsive behaviours in PD could have implications for treatment.

The primary treatment for ICDs in PD is to reduce or discontinue dopamine agonist therapy (Mestre et al., 2013; S. Zhang et al., 2016). This is problematic, as ceasing dopamine agonist therapy elicits a range of negative withdrawal symptoms that some people with PD cannot tolerate (Samuel et al., 2015). Furthermore, reducing dopamine agonists can significantly worsen the motor symptoms associated with PD (S. Zhang et al., 2016). Medications typically used to treat ICDs in the general population, such as neuroleptic drugs, are not suitable for use in PD as they can worsen motor symptoms (Mestre et al., 2013). For these reasons, the use of non-

pharmacological interventions is more preferable for the management of impulsive behaviours in PD (Samuel et al., 2015).

Only one study has examined the use of a non-pharmacological intervention to manage impulsivity issues in PD. Using a randomised control trial Okai et al. (2013) assessed the effectiveness of a cognitive behavioural therapy intervention for reducing impulsivity issues in PD. Participants in the intervention group received 12 sessions of therapy, while the control group were assigned to a waiting list. Following the treatment, 79% of people in intervention group were found to have improved compared to 29% in the control group. Additionally, the intervention group demonstrated a significantly greater reduction in other outcomes such as anxiety and depression. This provides some preliminary support for the use of cognitive behavioural therapy in treating ICDs in PD. Further non-pharmacological studies for the management of impulsivity in PD are required.

The finding that ICDs could be driven by an over attraction to reward may help to account for the success of the cognitive behavioural therapy. As part of their intervention, Okai et al. (2013) promoted 'pleasant activity scheduling', where participants had to schedule times to engage in activities that they find pleasurable that were not associated with their impulsive behaviours. Rather than focusing on the negative consequences of engaging in impulsive behaviours (which based on our results is not related to the engagement in these behaviours), Okai et al. (2013) encouraged the participants to find and engage in alternative behaviours that they also find rewarding. If attraction to reward underlies ICDs, the cognitive behaviour therapy was probably effective because it re-directed attraction to reward to more benign but still rewarding behaviours, rather than allowing the participants to fixate on one specific problematic behaviour.

4.5.10 Behavioural activation

Based on the present results, an approach to therapy that might be relevant to impulsive behaviours in PD is behavioural activation therapy (Russo, Tirrell, Busch, & Carpenter, 2018). The emphasis of behavioural activation therapy is on the relationship between reinforcement and behaviour (Hunnicutt-Ferguson, Hoxha, & Gollan, 2012). In depression, the therapy requires a person to schedule rewarding activities throughout their day so that they begin to initiate approach behaviours (pursuing rewards in their environment; Kanter, Puspitasari, Santos, & Nagy, 2012).

Consequently, people using behavioural activation therapy can overcome the anhedonia associated with depression (Kanter, Puspitasari, Santos, & Nagy, 2012). Rather than focusing on negative content, the therapy guides the client towards healthy behaviours that they find rewarding (Kanter et al., 2012). The therapy has been shown to alter activation in reward circuitry in the brain (such as the striatum) post treatment (Dichter et al., 2009). These reward areas are also implicated in impulsivity in PD (O'Sullivan et al., 2011). Given the present findings also emphasise the importance of reward seeking behaviours in impulsivity for people with PD, interventions such as cognitive behavioural therapy and behavioural activation therapy could be useful in the management of impulsive behaviours in PD. These therapies aim to guide a person's attraction to reward towards alternative healthy behaviours, rather than focusing on avoiding the negative consequences associated impulsive behaviours.

4.5.11 Limitations

There are several imitations that need to be acknowledged in interpreting the current findings. The results indicated that the QUIP-RS accounted for more variance in the SERB than the BIS/BAS scale. However, the QUIP and the SERB for the most part ask about engagement in specific behaviours, whereas the BIS/BAS scale assesses general tendencies. The stronger correlation between the QUIP-RS and the SERB might be a result of a similar style of questioning. Larsen, Nevo, and Rich (2008) argued that shared variance between measures could reflect similarities in item wording, rather than relationships between the constructs they measure. Recent research has demonstrated that the semantic overlap between measures can explain a large amount of the variance that they share (Arnulf & Larsen, 2014; Nimon, Shuck, & Zigarmi, 2016). This means that relationships detected between questionnaires could be an artefact resulting from similar item wording, which could apply to the observed relationship between the QUIP-RS and the SERB. Both of these measures ask about engagement in behaviours rather than general tendencies like the BIS/BAS scale. To overcome this, future research could use a face to face assessment of impulsive behaviours administered by a clinician to determine whether a person engages in the behaviours assessed by the QUIP-RS and the SERB. This would determine whether these behaviours are comorbid without relying on self-reported measures which could be biased by item wording.

4.5.12 Significance

The findings of this study add to our understanding of impulsive behaviours in PD. This study is novel as it demonstrates that scores on the QUIP-RS relate to impulsive behaviours beyond those it directly assesses. Future research should therefore consider a broader scope of impulsive behaviours in PD. This study also has practical implications for clinical practice. For clinicians, a person with PD who is identified by the QUIP-RS has having an ICD might also be engaging in other risky behaviours. Clinicians should be cognisant of other (than those measured by the QUIP) potential impulsive behaviours that may be a problem for people with PD. The present results also suggest that impulsivity in PD is related to the attraction to reward rather than the fear of punishment. As such, when managing impulsive behaviour clinicians should focus on the person's attraction to the rewarding aspects of the impulsive behaviours, rather than the negative consequences associated with them.

Chapter 5 Study 2: Examining the impact that insight has on the relationship between self-reported impulsivity and self-reported risky behaviours in PD

5.1 Introduction

Research has suggested that people with PD may have reduced insight, partly due to the impairment of frontal brain areas associated with PD progression (Kudlicka et al., 2013). However, research investigating insight in PD is limited (Lehrner et al., 2015). Reduced insight can lead to changes in a number of functional outcomes (Bloomfield, Woods, & Ludington, 2016). For example, impaired insight associated with normal ageing reduces a person's capacity to accurately estimate their own abilities (Volz-Sidiropoulou & Gauggel, 2012). For people with neurological diseases, reduced insight is particularly problematic as it diminishes a person's ability to recognise their own limitations (Rosen, 2011). If a person does not recognise difficulties that result from their disease, they can be less receptive to treatment (Rosen, 2011). People with reduced insight may also try to engage in activities that they are no longer capable of doing safely (Rosen, 2011). In PD, insight enables people to recognise changes associated with their condition so that they can report these changes to their clinician and make accommodation for changes in their everyday life (Bloomfield et al., 2016; Kudlicka et al., 2013). This is particularly important for complications of PD that are less obvious than motor symptoms, such as impulsive behaviours, which may be under-reported in PD due to impaired insight (Weintraub et al., 2015).

5.1.1 Insight in PD

A number of studies indicate that people with PD fail to report a number of changes that associated with PD, such as underestimating their motor impairments (Amanzio et al., 2010). Maier and Prigatano (2017) found that people with PD have an impaired awareness of their motor symptoms. In their study, PD participants observed an experimenter performing an action (such as rising from a sitting position). The participants were then asked to carry out the same movement themselves and rate how well they performed the movement. The results indicated that 44% of the participants did not recognise that some of their movements were

impaired, demonstrating that some people with PD interpreted their motor performance as being better than it actually was, which may have implications for therapy, functionality, and quality of life.

Olfactory issues affect up to 90% of people with PD, but many remain unaware of changes relating to their sense of smell (Doty, 2012a; Kawasaki, Baba, Takeda, & Mori, 2016). Kawasaki et al. (2016) explored whether people with PD were aware of their impaired sense of smell. They found that (compared to healthy controls) people with PD were less likely to be aware that they had olfactory issues. Furthermore, the PD participants with mild cognitive impairment were significantly less able to recognise their olfactory deficits (compared to those without mild cognitive impairment). The authors suggested that cognitive impairments might reduce insight in PD.

Reduced insight in PD also impacts upon the ability to recognise issues relating to cognition. Kudlicka et al. (2013) examined whether PD participants with executive functioning deficits were aware of their impairments. The participants were asked to estimate their executive abilities, such as their ability to sustain attention, solve problems, regulate their emotions, and complete daily tasks. They then completed a number of behavioural measures that objectively assessed their executive functions. Those with executive functioning deficits overestimated their executive abilities, performing poorly on the objective measures compared to their self-reported appraisal of their performance. Consistent with these findings, Lehrner et al. (2015) compared PD participants with memory issues to PD participants with no cognitive impairments. Like Kudlicka et al. (2013), participants were required to estimate their own memory abilities and then complete some behavioural memory tasks. PD participants with no cognitive impairments accurately reported their memory abilities, and their appraisal of their memory corresponded with their performance on memory tasks. Conversely, those with memory issues overestimated their memory ability, rating their memories as being better than their scores on the tasks would suggest.

5.1.2 Insight and ICDs

Although the research is limited, some studies have investigated whether people with Impulse Control Disorders (ICDs) have impaired insight (Pineau et al., 2016). Brevers et al. (2013) examined whether pathological gamblers had insight into

their decisions while completing a modified version of the Iowa Gambling Task. The modified version of the task required the participants to make an appraisal of their decisions during the task. The participants were asked to rate how confident they were in their decision, and how likely they thought it would be that they would win based on their choice. The pathological gamblers performed worse (more impulsively) on the gambling task compared to a control group (matched for age and gender). Furthermore, the control participants were more conservative in their appraisal of their choices than the pathological gamblers. The pathological gamblers were more confident in their choices and overestimated the likelihood that they would win, despite choosing the riskier options during the task. Brevers et al. (2014) followed up their initial study to see if pathological gamblers would have insight into their abilities on a non-gambling task. The gamblers and a control group completed a grammar task. The control group's appraisal of their performance correlated with their performance on the task, but the gamblers struggled to gauge how well they had performed (their appraisals did not correlate with their performance). The authors suggested that the results of these two studies demonstrate a lack of insight in pathological gamblers.

Research has indicated that people with PD and ICDs may have reduced insight (Baumann-Vogel et al., 2015; Fasano et al., 2010). Based on their observations in clinical practice, Baumann-Vogel et al. (2015) predicted that relying on people with PD to self-report their impulsive behaviour might underestimate the actual extent of these behaviours. They noted that some people with PD in their clinical practice did not disclose having an ICD, but would later be diagnosed as having an ICD. This was usually the result of a clinician noticing these issues after spending an extended time with the person with PD, or family members voicing their concerns about the person's impulsive behaviours. Based on their observations, Baumann-Vogel et al. (2015) administered a screening measure for ICDs to both the person with PD and their caregiver. The results revealed that the caregivers reported significantly more ICDs than the people with PD. Compared to the PD participants, the caregivers reported significantly higher rates of hypersexuality, punding, and dopamine dysregulation syndrome. In contrast, only in 7 of the 92 identified ICDs was it the person with PD who reported having an ICD when their caregiver did not. Baumann-Vogel et al. (2015) concluded that the PD participants with ICDs might not be aware of their problematic behaviours, which contributed to them under-reporting

ICDs compared to the caregivers. Alternatively, it is possible that the caregivers over-reported the incidence of ICDs.

Mack et al. (2013) investigated whether insight and executive functioning differed between PD participants with an ICD and without an ICD. The authors predicted that people with an ICD would have lower insight. A series of executive functioning measures were administered to both groups, in addition to a self-reported assessment of insight (Beck Cognitive Insight Scale). The results revealed that the groups did not significantly differ on any of the measures of executive functioning. Furthermore, contrary to the author's predictions, the scores for the Beck Cognitive Insight Scale indicated that the ICD group had greater insight than the non-ICD group. While this was unexpected, the results of the executive functioning tasks may account for these unusual findings. The results of executive functioning tasks for this study suggest that those with PD and an ICD did not have impaired frontal functioning compared to the non-ICD group. That is, neither group demonstrated any deficit in executive functioning. This may explain why the ICD participants did not demonstrate impaired insight. As discussed in chapter two, insight is thought to be heavily dependent on frontal areas of the brain (Fletcher & Carruthers, 2012). If the ICD group had relatively intact executive functioning, then it would be expected that their insight would also be intact. The finding that the ICD group was not impaired in terms of executive functioning appears to be an anomaly. A recent meta-analysis concluded that people with PD and ICD are impaired in several areas of executive functioning compared to those with no ICD (Santangelo et al., 2017). If people with ICDs in PD experience impairments to some executive functions, it might be expected that they have would also have impaired frontal functioning and, consequently, would have reduced insight. Mack et al. (2013) suggested that their unexpected results could be due to their somewhat small sample size (n = 34).

The current study consists of two parts. Part one examines how insight (assessed using the Beck Cognitive Insight Scale) differs between PD participants with an ICD and those with PD and no ICD. This extends the research by Mack et al. (2013) by including nearly twice as many participants, which may provide a clearer understanding as to whether people with PD and ICD demonstrate impaired insight. It is hypothesised that the PD participants with an ICD will demonstrate reduced insight compared to those with no ICD. Part two explores the contribution of insight to the self-reporting of impulsive behaviours. As previously discussed, research has

suggested that relying on people with PD to self-report their impulsive behaviours might be result in the extent of these behaviours being underestimated, due to issues with insight in PD (Baumann-Vogel et al., 2015; Weintraub et al., 2015). It is predicted that insight will moderate the relationship between self-reported impulsivity and actual engagement in impulsive behaviours. Lower insight is expected to reduce the relationship between self-reported impulsivity and engagement in impulsive behaviours. This would demonstrate that reduced insight impairs the ability to accurately self-report impulsivity.

5.2 Hypotheses

1. Participants identified as having an ICD by the QUIP-RS will have significantly lower insight (as measured by the Beck Cognitive Insight Scale) than those identified as having no ICD.
2. The relationship between the QUIP-RS and frequency of risky behaviours (SERB) will be partially moderated by insight (as measured by the Beck Cognitive Insight Scale composite score), such that lower insight will reduce the relationship between the QUIP-RS and the SERB.

5.3 Analyses

The data were analysed using SPSS version 24 and Mplus version 7.4. All assumptions were met, with the exception of the assumption of homogeneity of variances - which was violated for the composite scores on the Beck Cognitive Insight Scale (for the independent sample t-test). To address this, the values for the equal variances not assumed are reported for composite scores on the Beck Cognitive Insight Scale.

An independent samples t-test explored whether participants identified as having an ICD demonstrated significantly lower insight than those identified as having no ICD. The participants were categorised as ICD positive or ICD negative based on their scores on the QUIP-RS. To minimise the number of false positives, participants were categorised according to the recommendations of Papay et al. (2011). Papay et al. (2011) suggested that a person should only be considered ICD positive according the QUIP if both the person with PD and their nominated

informant agree that a particular ICD is present. So if either the person with PD or their informant scored an ICD as not being present, then they were not categorised as having that ICD. This reduces the false positive rates that have been previously identified as an issue for the QUIP (Probst et al., 2014; Weintraub et al., 2012).

A moderation model (using Mplus version 7.4) using OLS linear regression tested whether the relationship between the QUIP-RS and frequency of risky behaviours was partially moderated by insight. The QUIP-RS (total score) and the Beck Cognitive Insight Scale (composite score) were regressed onto the SERB (total score). An interaction term between the QUIP-RS and the Beck Cognitive Insight Scale composite score was calculated. This interaction term was also regressed onto the SERB total score.

5.4 Results

Demographic data for the participants is provided in the general methods section, including a comparison of participants with and without ICDs (according to their QUIP-RS scores). The independent samples t-test indicated no difference between the groups in terms of the composite score on the Beck Cognitive Insight Scale. The ICD positive group (n = 32, M = 4.84, SD = 3.33) did not significantly differ from the ICD negative group (n = 34, M = 3.79, SD = 5.09), t(57.3) = .99, p = .32, d = 0.22. Given that no difference was found between the groups in terms of the composite score, further t-tests were run to detect any differences between the groups on the remaining two factors of the Beck's Cognitive Insight Scale - self-reflectiveness and self-certainty. No significant differences were found between the groups for self-reflectiveness, ICD positive (n = 32, M = 11.16, SD = 3.35) ICD negative (n = 34, M = 9.85, SD = 4.35), t(64) = 1.36 , p = .18, d = 0.30. Similarly, no significant differences were observed between the groups in terms of self-certainty, ICD positive (M = 6.31, SD = 2.36) ICD negative (M = 6.06, SD = 3.11), t(64) = .37, p = .71, d = 0.2.

Kao and Liu (2010) examined the psychometric properties of the Beck Cognitive Insight Scale in a sample of 180 Taiwanese participants. Based on the results of their factor analysis, they determined that the original factor structure did not fit their data well and proposed an alternative factor structure. Their alternative structure still contained two factors (self-reflectiveness and self-certainty), but a

couple of the items had a stronger loading on the opposing factor in comparison to the original factor structure. In the event that this alternative factor structure was more applicable (than the traditional factor structure) to the present sample, the data were reanalysed using the alternative factor structure. All assumptions for the independent samples t-test were met. The test indicated that the ICD positive group had significantly higher composite score than the ICD negative group, ICD positive (M = .47, SD = 4.83), ICD negative (M = -2.09, SD = 3.84), $t(64) = 2.39$, $p = .02$, d = .59.

The Mplus moderation model indicated that the QUIP-RS was significantly associated with scores on the SERB (as would be expected from the results of chapter four, study one). However, the interaction term was not significant, indicating that the relationship between the QUIP-RS and the SERB was not moderated by the Beck Cognitive Insight Scale composite score.

The first model indicated that the Beck Cognitive Insight Scale composite score did not moderate the relationship between the QUIP-RS and the SERB. To more comprehensively examine whether self-reported impulsivity is affected by insight, further analyses were conducted. While the ability to self-report the presence of ICDs (QUIP-RS) does not appear to be affected by insight, self-reported attraction to reward could be. In study one, the BAS factors were associated with the SERB. This relationship was explored further to determine whether the relationship between the BAS factors and the SERB are moderated by the Beck Cognitive Insight Scale composite score. Both the BAS Drive and BAS Funseeking factors were significantly associated with the SERB, but the interactions terms were not significant. This suggests that Beck Cognitive Insight Scale composite score does not moderate any of the observed relationships. The moderation models are summarised in Table 5.1.

Table 5.1 Standardised (β) regression coefficients for QUIP-RS, BAS factors, Beck Cognitive Insight Scale, and interaction terms regressed on the SERB.

	β (standardised)	Standard error	*p* value	R^2^
SERB on				
QUIP-RS**	.57	.16	<.001	.31**
BCIS	.02	.19	.92	
Interaction	-.03	.25	.92	
SERB on				
BAS Drive*	.36	.14	.01	.17*
BCIS	-.15	.42	.64	
Interaction	.20	.44	.72	
SERB on				
BAS Fun*	.46	.14	.001	.17*
BCIS	.24	.42	.53	
Interaction	-.28	.45	.58	
SERB on				
BAS Reward	.32	.20	.11	.07
BCIS	.33	.61	.59	
Interaction	-.30	.64	.64	

Note: BCIS (Beck Cognitive Insight Scale). β coefficients are standardised in terms of units of measurement.
**p < .05 (two tailed) **p < .001 (two tailed)*
^R^2 value represented the amount of variance that the indepdent variables accounted for in the dependent variable.

As already indicated, the alternative factor structure proposed by Kao and Liu (2010) could be more applicable to the present sample. The models were therefore re-run using this alternative factor structure. The QUIP-RS (total score) and BAS (Drive and Funseeking) demonstrated significant correlations with the SERB. However, these relationships were not moderated by the Beck Cognitive Insight Scale composite score as the interaction terms were non-significant. The results of the models are shown in Table 5.2.

Table 5.2 Standardised (β) regression coefficients for QUIP-RS, BAS factors, Beck Cognitive Insight Scale, and interaction terms regressed on the SERB. Alternative factor structure used for the Beck Cognitive Insight Scale.

	β (standardised)	Standard error	*p* value
SERB On			
QUIP-RS**	.56	.10	<.001
BCIS	.15	.19	.45
Interaction	-.13	.19	.52
SERB On			
BAS Drive**	.42	.11	<.001
BCIS	.07	.43	.87
Interaction	.19	.43	.66
SERB On			
BAS Fun*	.34	.12	.004
BCIS	.36	.47	.44
Interaction	-.17	.46	.71
SERB On			
BAS Reward	.21	.11	.07
BCIS	1.13	.67	.19
Interaction	-.88	.67	.09

BCIS Beck Cognitive Insight Scale. β coefficients are standardised in terms of units of measurement.
**p < .05 (two tailed)*
***p < .001 (two tailed)*

5.5 Discussion

The first hypothesis was not supported by the current results. The ICD positive and ICD negative PD groups did not significantly differ on any of the three factors of the Beck Cognitive Insight Scale. This indicates that people with ICDs in PD do not have impaired insight. However, Kao and Liu (2010) proposed an alternative factor structure for the Beck Cognitive Insight Scale. Using this alternative factor structure, the results suggest that the ICD positive group had significantly higher insight than the ICD negative group (indicated by a higher composite score on the Beck Cognitive Insight Scale). The finding that insight is

greater in the ICD positive group contradicts the first hypothesis, which predicted that the ICD positive group would have lower insight than the ICD negative group.

The second hypothesis was also not supported by the current findings. While the QUIP-RS, BAS Drive, and BAS Funseeking positively correlated with the SERB, none of these relationships were moderated by the Beck Cognitive Insight Scale composite score. This demonstrates that insight does not moderate the relationship between their self-reported impulsivity (QUIP-RS and BIS/BAS scale), and the engagement in impulsive behaviours (SERB). It was predicted that higher insight would enable a person to more accurately appraise their own impulsivity and, therefore, their self-reported impulsivity would more closely align with the risky behaviours they engage in. The present results do not suggest that this is the case. The strength of the relationship between self-reported impulsivity and the engagement in impulsive behaviours did not change depending on the person's insight.

5.5.1 Insight and ICDs in PD

Braak, Del Tredici, et al. (2003) explained that in the later stages of PD, α-synuclein accumulates in frontal areas of the brain negatively affecting abilities dependent on these areas. Furthermore, the changes to frontal dopaminergic pathways associated with PD are also thought to contribute to disrupted frontal functioning (Gratwicke et al., 2015). Correspondingly, research has observed that abilities dependent on these areas (such as executive functions) are negatively affected in PD (Kudlicka, Clare, & Hindle, 2011). Insight is also dependent on frontal functioning (David, Bedford, Wiffen, & Gilleen, 2012; Fletcher & Carruthers, 2012), and as would be expected, it has been observed that people with PD have a lack of insight concerning their motor and cognitive difficulties (Kudlicka et al., 2013; Lehrner et al., 2015; Maier & Prigatano, 2017).

Although insight is likely to be affected in PD, it was expected that people with PD and an ICD would have poorer insight than people with PD and no ICD. This is because impulsivity is associated with impaired frontal functioning, and correspondingly, frontal impairments in PD are thought to contribute towards the development of ICDs (O'Callaghan et al., 2013). Insight is also dependent on frontal functioning (David et al., 2012). Therefore, as people with ICDs in PD are thought to have particularly impaired frontal functioning, it was expected that they would

experience greater reductions to insight than those without ICDs. Research generally suggests that people with PD have reduced insight, but research investigating whether insight differs for people with impulsivity issues in PD is limited. As previously mentioned, only the study by Mack et al. (2013) has examined whether PD participants with and without an ICD differ in terms of insight. Mack et al. (2013) unexpectedly found that people with an ICD scored higher on the composite score of the Beck Cognitive Insight Scale, indicating that they had higher insight than the ICD negative group. Although unexpected, the findings of Mack et al. (2013) fit with the present results. The present study is larger than the study by Mack et al. (2013), with nearly twice the number of participants. Building upon their findings, the present study found that using the original factor structure of the Beck Cognitive Insight Scale the ICD positive and negative groups did not differ on the composite score. However, when the alternative structure for the scale was used the results were consistent with Mack et al. (2013), such that the ICD positive group study had higher insight than the ICD negative group. Therefore, the current findings further support to suggest that people with ICDs in PD do not demonstrate issues with insight, beyond those experienced by people with PD and no ICDs. In fact, the findings of the present research and those of Mack et al. (2013) would indicate that people with ICDs in PD have better insight than those with no ICDs.

5.5.2 Insight, executive functioning, and frontal impairments

The finding that ICD group did not differ significantly from non-ICD for insight is unexpected and requires further exploration. First, it is necessary to explore the links between ICDs and executive functioning in PD. Executive functioning has been linked to insight in other clinical groups with cognitive impairment, such as in people with schizophrenia (Chan et al., 2014). Therefore, if people with ICDs in PD consistently demonstrate executive impairments (compared to those with no ICDs), it is reasonable to expect they would also have impaired insight. As discussed in chapter two, a multitude of studies have shown that people with ICDs in PD have cortical thinning in frontal areas and show reduced activation of these areas. It would be expected that this would correspond with executive impairments and impaired insight, as these abilities depend on frontal areas (Chan et al., 2014; O'Callaghan et al., 2013).

Two recent studies have reviewed executive impairments in people with PD and ICDs compared to people with PD without ICDs. Santangelo et al. (2017) conducted a meta-analysis to determine whether people with ICDs in PD have greater impairments in executive functions. They concluded that while the findings of research examining executive functions in PD participants with and without ICDs are mixed, several areas of executive functioning appear to be consistently impaired in people with ICDs. Of the 20 areas of executive functioning reviewed by Santangelo et al. (2017) four were consistently impaired in PD participants with ICDs (set shifting, concept formation, spatial reasoning, and decision making). Santangelo et al. (2017) concluded that people with ICDs and PD have specific executive dysfunctions rather than a general decline in executive functioning Martini, Lago, Edelstyn, Grange, and Tamburin (2018) conducted a similar meta-analysis with slightly stricter inclusion criteria than Santangelo et al. (2017). Martini et al. (2018) reported that ICD positive participants performed worse on some aspects of executive functioning, but like Santangelo et al. (2017), also concluded that many aspects of executive functioning remained intact. This was somewhat unexpected as the authors predicted that the disruptions to frontal functioning associated with ICDs in PD would also result in greater impairments to executive functions (Martini et al., 2018). Therefore, while impulsivity in PD is associated with greater frontal impairments compared to people with PD and no impulsivity issues (Clark & Dagher, 2014; Voon, Gao, et al., 2011), executive abilities that are dependent on these areas seem to remain relatively intact. Potentially, insight is another ability that is relatively unaffected by the frontal dysfunction observed in people with PD and ICDs.

5.5.3 Insight is intact for people with ICDs and PD

The present results, alongside the results of Mack et al. (2013), suggest that insight is actually higher in people with PD and ICDs compared to those with no ICD. In support of this, despite frontal impairments being observed in people with PD and an ICD (O'Callaghan et al., 2013), most executive functioning abilities remain similar to those without an ICD (Martini et al., 2018). These findings suggest that while changes to frontal areas could make people with PD more likely to develop an ICD, it does not necessarily mean that other abilities dependent on these areas (such as executive functions and insight) will also be impaired. It is also worth

noting that while many researchers agree that the frontal areas of the brain are important for insight, other areas in the parietal and temporal lobes have been associated with insight (David et al., 2012; Valk, Bernhardt, Böckler, Kanske, & Singer, 2016). This means that frontal impairments alone may not impact upon insight, or at least that insight will not be affected by frontal impairments to the same extent that other abilities dependent on these areas will be. In light of this, it is reasonable to suggest that the present results are valid and that insight is not impaired in people with PD and ICDs compared those without ICDs.

The conclusion that insight is not affected in people with PD and ICDs is also congruent with the findings of the previous chapter. In chapter four (study one), it was reported that behavioural activation/attraction to reward was related to impulsive behaviours in PD. Conversely, behavioural inhibition/the fear of punishment did not relate to impulsive behaviours. Frontal activation is thought to be related to the suppression of impulsive behaviours, as frontal functioning allows a person to evaluate the negative consequences associated with engaging in an impulsive behaviour (Bechara, 2005; Ferenczi et al., 2016; Martini et al., 2018). As fear of punishment was not related to impulsivity in study one, perhaps it is not the impairments to frontal areas associated with PD that underlie impulsivity. This may explain why studies such as Martini et al. (2018) and the current results do not indicate clear deficits in abilities dependent on frontal areas for impulsive people with PD (compared to non-impulsive people). Frontal areas might be impaired, but this may not be significantly more so than non-impulsive people with PD. Alternatively, it is possible that impairments to frontal areas differentially affect separate functions. The inhibition of impulsive behaviours may be more susceptible to frontal impairments than executive functions or insight. The results could also mean that rather than frontal changes, it is disruptions to dopaminergic limbic systems that underlies impulsive behaviours in PD. Limbic areas are thought to drive the attraction to reward (Bechara, 2005), and in study one, it was the attraction to reward that was significantly associated with impulsivity. Indeed, Martini et al. (2018) argued that impulsivity in PD results from dopaminergic medications overdosing limbic reward pathways, a view shared by a number of researchers (Averbeck et al., 2014; Voon, Gao, et al., 2011). If functional changes in limbic, rather than frontal areas underlie impulsivity in PD, then it would make sense that

abilities such as executive functions and insight are not any different in PD for people with ICD than for people without ICD.

5.5.4 The Beck Cognitive Insight Scale

An alternative explanation for the present results is that the Beck Cognitive Insight Scale does not capture insight in PD. Most research into insight has focused on people with schizophrenia and psychosis (David et al., 2012), which are the populations that the Beck Cognitive Insight Scale was validated in (Beck et al., 2004). Van Camp, Sabbe, and Oldenburg (2017) recently reviewed the Beck Cognitive Insight Scale and acknowledged that the scale is the most widely used measure of cognitive insight. However, the authors also concluded that while the scale had demonstrated validity for use in schizophrenic and psychotic populations, limited research has used the scale outside of these specific populations. Therefore, the validity of the Beck Cognitive Insight Scale in other populations such as PD has not been established. Only the study by Mack et al. (2013) has used the scale in PD. Another study by Degirmenci, Degirmenci, Düğüncü, and Yılmaz (2013) used the measure to examine whether people with Alzheimer's differed on the Beck Cognitive Insight Scale compared to normal controls. Degirmenci et al. (2013) found no difference between the groups in terms of the composite score, which is indicative of overall insight. In light of these findings, the use of the Beck Cognitive Insight Scale in PD may limit the conclusions that can be drawn from the present findings. It may be that PD requires the development of a specific measure of insight.

In support of the current use of the Beck Cognitive Insight Scale, some research has demonstrated that performance on the measure is related to frontal functioning. Several studies have found that higher scores on the self-reflectiveness factor of the Beck Cognitive Insight Scale (which indicates greater insight) are associated with higher activation in prefrontal areas (Buchy et al., 2014; Pu et al., 2013; van der Meer et al., 2013). Higher composite scores on the Beck Cognitive Insight Scale (also indicating greater insight) have also been linked to increased recruitment of prefrontal areas and the posterior cingulate cortex in people with schizophrenia (Lee, Chun, Lee, Seung-Koo, & Jae-Jin, 2015; L. Zhang, Opmeer, Ruhé, Aleman, & van der Meer, 2015). These results suggest that greater insight as measured by the Beck Cognitive Insight Scale, is associated with recruitment of prefrontal areas in the brain. Correspondingly, higher reflectiveness scores on the

Beck Cognitive Insight Scale have also been linked to greater cortical thickness in prefrontal areas for people with schizophrenia and psychosis (Buchy et al., 2016).Although the Beck Cognitive Insight Scale has primarily been validated in populations with schizophrenia and psychosis, scores on the scale do seem to be associated with frontal functioning. This suggests that the Beck Cognitive Insight Scale is able to capture the loss of insight that is associated with impairments to frontal areas. As people with PD experience declines in frontal functioning, the scale should capture any associated changes in insight resulting from impaired frontal functioning. For this reason, the Beck Cognitive Insight Scale was deemed suitable for use in the current study.

The Beck Cognitive Insight Scale has, to date, only been evaluated for use in psychotic and schizophrenic populations (Van Camp et al., 2017). Future research should investigate the validity of the measure for detecting insight in PD. Given that insight has been noted to be an issue in PD, it is important that validated scales for examining insight in PD are developed. Without such research, it is difficult to determine if the current finding of a difference between the ICD positive group and the ICD negative group reflects a true difference in insight. Viable alternatives to the Beck Cognitive Insight Scale are limited (David et al., 2012). The more widely used alternatives are semi-structured interviews, but these have their own limitations and are not always practical for research purposes (David et al., 2012).

Despite the limitations associated with using the Beck Cognitive Insight Scale in PD, some tentative conclusions can be drawn from the present results. Comparisons between the present sample and other normative samples need to be tentative, due to the tendency for scores on the Beck Cognitive Insight Scale to unexpectedly vary between clinical and non-clinical samples (Penney, Sauvé, Joober, Malla, & Lepage, 2018). That said, the overall mean for the composite score in the present sample ($M = 4.3$, n = 66) was slightly higher than the normative data ($M = 4.2$, n = 142) provided by Buchy et al. (2012), and was higher than another large sample of healthy controls ($M = 3.2$, n = 148) used by Penney et al. (2018). This suggests that insight is not impaired in the current PD sample for both the ICD positive and ICD negative groups (as a higher average composite score would indicate better insight).

5.5.5 Insight as a moderator

The present results did not support hypothesis two. Insight did not moderate the relationship between self-reported impulsivity and the engagement in impulsive behaviours. This indicates that higher levels of insight are not necessary for a person to be able to report their impulsivity. Although this finding is unexpected, it does suggest that people with PD have the ability to successfully report their own impulsivity. The presence of relationships between the self-reported impulsivity (BAS Drive, BAS Fun, and the QUIP-RS) and the engagement in risky behaviours (SERB) suggests that people with PD retain the ability to report their impulsivity accurately. If insight was significantly impaired, such relationships would not be observed. The positive aspect of the present findings is that lower insight did not reduce the strength of the relationship between self-reported impulsivity and risky behaviours. This suggests that the participant with the lowest insight in the present sample was still able to successfully self-report their impulsivity.

5.5.6 Practical applications

The present findings suggest that people with ICDs in PD are not any more impaired in terms of insight than those without an ICD. They also suggest that insight in the present sample was not impaired compared to normative samples. Furthermore, impulsivity as measured by both the QUIP-RS and the BIS/BAS scale were correlated with the engagement in impulsive behaviours, which did not depend on the level of the participant's insight. These results mean that clinicians can be reasonably confident that people with PD are able to successfully self-report their impulsivity. This adds credibility to the use of the QUIP-RS as a screening measure for impulsive behaviours in PD, as the validity of the measure did not appear to be dependent on insight. Leeman et al. (2012) have suggested using the QUIP in clinical settings for this purpose. Previous research has raised concerns that ICDs in PD might be under-reported (Baumann-Vogel et al., 2015; Weintraub et al., 2015). The present results suggest that this is not an issue, and that people with ICDs in PD have the insight to be able to successfully report whether they experience issues with impulsive behaviours. Therefore, the under-reporting of impulsive behaviours in PD might be due to people being uncomfortable or embarrassed about disclosing these behaviours, rather than any issues with insight (Weintraub et al., 2015). This is unlikely to be an issue for the present study, as participants self-elected to take part

knowing that the research project would require them to disclose any impulsive behaviours that they engage in. Future research should examine whether the sensitive nature of these behaviours is impacting upon the reporting of impulsive behaviours, and how this could be addressed in a clinical setting.

5.5.7 Limitations

It is possible that a self-selection bias limits the results of the current study. The recruitment for the study depended on people with PD who were willing and able to take part in the research. This may favour a certain demographic of people with PD, especially people with higher functioning and potentially more insight or self-reflection. Research in other clinical populations has shown that higher functioning individuals with better cognitive performance are more likely to take part in research (Kline et al., 2018). The present results could be a consequence of higher functioning people taking part in the research, which would explain why insight did not moderate the relationship between self-reported impulsivity and the engagement in impulsive behaviours. This would also explain why no difference was observed between the ICD positive and ICD negative groups. However, the standard deviation for the composite scores (M = 4.3, SD = 4.3) and the range of composite scores (-5 to 14) would suggest fair amount of heterogeneity in current sample. Furthermore, the study could be limited if only recently diagnosed people with PD took part, as impairments to frontal areas are thought to take place later on in the progression of PD (Braak, Ghebremedhin, Rüb, Bratzke, & Del Tredici, 2004). However, this is not likely to be an issue as the mean years of Parkinson's duration in the current sample was (M = 8.2, SD = 5.5), with a range of 0-29 years since diagnosis.

Another consideration for the current study is that all the data was self-reported. As David et al. (2012) noted, the Beck Cognitive Insight Scale asks participants to reflect on how reflective they are, which can be problematic. Also, the engagement in risky behaviours as examined by the SERB is self-reported. Therefore, the data regarding the engagement in risky behaviours could also be influenced by individual differences in insight. Ideally an objective measure of insight would be appropriate. This would allow researchers to determine if higher insight allows people to more accurately self-report their own impulsivity compared to an objective score (i.e., does better insight mean that self-reported impulsivity will more closely align with an objective measure of impulsivity?) Some researchers have

noted that behavioural impulsivity tasks might provide an objective means of measuring underlying impulsivity traits (Sharma et al., 2014). While behavioural tasks of impulsivity have been noted to have some limitations (King et al., 2014), it is worth exploring the usefulness of these measures for assessing impulsivity in PD. As discussed in the introduction of this thesis, both Kudlicka et al. (2013) and Lehrner et al. (2015) used objective behavioural tasks in a similar manner to investigate the awareness of cognitive deficits in PD.

The present study discusses the link between impaired executive functioning, impulsivity, and insight. However, executive functioning was not assessed in the present sample, which limits the present study as the expected associations between the examined variables and executive functioning cannot be directly explored.

5.5.8 Significance

The current results demonstrate that insight in PD does not affect the ability of people with PD to report on their impulsivity. The current participants were able to successfully report their impulsiveness, as their scores on the QUIP-RS and BIS/BAS scale aligned with their engagement in impulsive behaviours. This relationship was not moderated by insight, demonstrating that participants with both higher and lower insight were able to assess and report their own impulsive tendencies. The present findings also illustrate that people with ICDs in PD do not have impaired insight compared to those with no ICDs in PD. Furthermore, when compared to normative data, the present PD sample did not have issues with insight. Overall, these results suggest that we can be reasonably confident in the ability of people with PD to self-report their impulsivity on screening measures such as the QUIP-RS. When clinicians administer these measures, they can have some assurance regarding that the quality of information they provide is sound. The role of the clinician may be to build adequate rapport with their clients to ensure that they are comfortable in disclosing impulsive behaviours, and overcome any issues with embarrassment (Weintraub et al., 2015). Once rapport has been built, measures such as the QUIP-RS are a useful tool for the assessment of impulsive behaviours.

Chapter 6 Study 3: Exploring the validity of behavioural impulsivity tasks in PD

6.1 Introduction

The assessment of impulsivity is a contentious area of research that is plagued by the poor relationship observed between self-report and behavioural measures of impulsivity (Duckworth & Kern, 2011; Sharma et al., 2013). This suggests that these methods may be reflecting different constructs, and raises the question as to which method provides the most valid assessment of impulsivity (Glicksohn, Hadad, & Ben-Yaacov, 2016). Developing methods for assessing impulsivity in PD is crucial to identifying impulsive people, so that they can receive treatment to minimise the impact that impulsivity has on their quality of life (Ramirez-Zamora et al., 2016). Both self-report and behavioural measures of impulsivity have numerous limitations and advantages (King et al., 2014), and it is imperative we understand which approach best suits PD research and relates to a person's actual engagement in impulsive behaviours. The following study provides a comprehensive overview of these commonly used methods to assess impulsivity, and evaluates the suitability of these approaches for use in PD.

6.1.1 Self-report impulsivity measures

As discussed in chapter two, self-report assessments are commonly used to measure impulsivity. Self-report assessments require a person to report on their own impulsive tendencies/behaviours (King et al., 2014). A person's responses to these measures are thought to reflect their underlying impulsive traits (Cyders & Coskunpinar, 2011). Self-reported impulsivity was initially conceptualised as being one higher order factor. However, there is now a growing consensus that self-reported impulsivity is comprised of numerous separate traits/factors (Sharma et al., 2013). For example, Whiteside, Lynam, Miller, and Reynolds (2005) proposed a widely used four factor model of impulsivity based upon self-report measures, the four factors being urgency, lack of premeditation, lack of perseverance, and sensation seeking (UPPS scale). While subsequent research has supported the idea that impulsivity consists of multiple factors, there is still disagreement on the exact factor structure (Duckworth & Kern, 2011; Sharma et al., 2013). King et al. (2014)

argued that impulsivity research was converging on a three factor model of impulsivity rather than a four factor model, a view supported by a number of researchers (Cross et al., 2011; Sharma et al., 2014). Although the exact nature of the underlying constructs that self-report measures of impulsivity capture remains unclear, these types of measures are useful in impulsivity research.

Self-report measures of impulsivity are relatively cheap and quick to administer (Cyders & Coskunpinar, 2011). This enables researchers to practically assess large groups of people, which means that the psychometric properties of self-report measures can be properly evaluated (Sharma et al., 2014). Impulsive traits measured by self-report questionnaires have been related to a number of problematic impulsive behaviours (Sharma et al., 2013). A meta-analysis by de Ridder, Lensvelt-Mulders, Finkenauer, Stok, and Baumeister (2011) investigated the relationship between self-report measures of impulsivity and behavioural outcomes. The results revealed that self-reported impulsivity was associated with a range of problematic outcomes, including drug taking, substance dependence, deviant behaviours (such as speeding), poorer workplace performance, and impaired social functioning. The relationship between self-reported impulsivity and impulsive behaviours is important, as it demonstrates that self-reported impulsivity has ecological validity regarding a person's engagement in 'real life' impulsive behaviours (Sharma et al., 2013)

Self-report measures of impulsivity are associated with numerous shortcomings. These measures assume that the participant has insight into their own impulsivity, and can report their underlying impulsive traits accurately (Emery & Levine, 2017). Self-report measures are subjective and vulnerable to biases, such as demand characteristics, whereby a participant's responses to a measure change if they determine the purpose of that measure (Haeffel & Howard, 2010). Personality can also affect self-reported abilities, people who are extroverted and conscientious tend to be more accurate in their self-appraisal compared to people who are more neurotic (Ackerman & Wolman, 2007). People generally have a 'self-enhancing' bias, whereby they tend to overestimate their own abilities and portray themselves in a 'favourable light' (Sedikides & Gregg, 2008). The shortcomings of self-reported assessments are of particular concern for PD research, as PD participants may lack insight into their own behaviours or may be inclined to hide their problematic behaviours (Weintraub et al., 2015).

Over 100 different self-report measures of impulsivity exist (Duckworth & Kern, 2011), which has lead researchers to question whether self-report measures of impulsivity suffer from the 'jingle fallacy' (Glicksohn et al., 2016). This is when measures that assess different constructs are incorrectly given similar names (Sharma et al., 2014). The jingle fallacy is a pertinent issue, as researchers may incorrectly assume that different impulsivity measures are capturing the same constructs when they are not (Sharma et al., 2014). Researchers may mistakenly draw comparisons between studies that employ self-report impulsivity measures which are assessing different constructs (Glicksohn et al., 2016). Issues with the jingle fallacy can also lead to difficulties in conceptualising a construct accurately as too many different constructs are given the same title, a problem that persists in impulsivity research (King et al., 2014).

6.1.2 Behavioural impulsivity measures

Behavioural tasks are another means of assessing impulsivity, a wide array of these tasks have been employed in the PD literature to examine impulsivity (Dawson et al., 2018). Behavioural tasks have typically been favoured in neuropsychology, as they enable researchers to study brain activation while participants complete the tasks (Duckworth & Kern, 2011). Behavioural tasks are thought to capture the behavioural manifestations of underlying traits, and are therefore considered an objective means of observing impulsive traits (Sharma et al., 2014). These tasks seek to mimic real-life situations by presenting participants with a situation/decision, the participant's responses can then be measured to directly observe how impulsively they behave (Enticott & Ogloff, 2006). Similarly to self-report measures, it has been suggested that separate factors/processes underlie performance on behavioural measures of impulsivity (Cyders & Coskunpinar, 2011). However, there is a lack of agreement in the literature as to what these processes are and how many separate processes exist (King et al., 2014). A number of studies have suggested there are five different cognitive processes that underlie performance on behavioural tasks of impulsivity, such as the inability to inhibit a prepotent response, and the inability to delay reward (Dick et al., 2010). In contrast, a meta-analysis by Sharma et al. (2014) factor analysed a large number of studies which used behavioural measures and produced four factors labelled inattention, inhibition, impulsive decision making, and shifting. Although there is limited agreement as to what behavioural impulsivity

measures are actually assessing, most researchers agree that these tasks measure several separate but related underlying constructs (King et al., 2014; Sharma et al., 2014).

Behavioural tasks have several advantages over self-report measures of impulsivity. They are not dependent on a person's level of insight and are therefore more appropriate for populations with reduced insight (Enticott & Ogloff, 2006). This suggests that they could be particularly useful for assessing impulsivity in PD due to the issues with insight that have been reported in PD (Kudlicka et al., 2013). Behavioural tasks are also thought to be more robust against deception than self-report measures, as it is more difficult for a participant to respond in a manner which hides their true characteristics (Cyders & Coskunpinar, 2011). Like self-report measures, behavioural tasks have also demonstrated predictive validity for 'real life' impulsive/risky behaviours. Impulsive behavioural tasks have been related to problematic alcohol consumption (Fernie et al., 2013; King et al., 2014). Performance on the Balloon Analogue Risk Task (BART) has been linked to behaviours such as gambling, smoking, and theft (Lejuez et al., 2002). Furthermore, clinical populations characterised by increased impulsivity (such as people with ADHD, obsessive compulsive disorder, compulsive eating, and psychopathic tendencies) perform more impulsively on behavioural tasks (Buelow & Suhr, 2009; Penadés et al., 2007; Price et al., 2013). Sharma et al. (2014) conducted a meta-analysis of 40 studies that examined the relationship between behavioural tasks and 'daily life impulsive behaviours'. The results indicated that on average, behavioural tasks of impulsivity significantly correlated with engagement in impulsive behaviours (r = .21), demonstrating their ecological validity as they related to the actual engagement in impulsive behaviours (although the strength of this relationship was very weak).

Behavioural impulsivity tasks also have several limitations. Performance on these tasks is dependent on, and reflective of, a person's ability across a range of cognitive domains (Sharma et al., 2014). This means that behavioural tasks are vulnerable to the 'task impurity problem' (Enticott & Ogloff, 2006), suggesting that they assess a number of processes simultaneously and do not specifically assess a single construct (Enticott & Ogloff, 2006). Compared to self-report measures, behavioural tasks are time consuming, difficult to administer, and expensive (King et al., 2014). As behavioural tasks are resource intensive and generally involve smaller

numbers of participants, there is limited research that evaluates their psychometric properties (Cyders & Coskunpinar, 2011). This raises the question as to whether these tasks assess underlying traits or whether they capture 'state like phenomena' that are not stable over time (King et al., 2014). Whilst the research is limited, a few studies have examined the test-retest reliability of behavioural measures. Stable scores would indicate that behavioural measures are assessing traits, rather than capturing behaviours that vary due to the person's state at the time of testing. Research examining the test-retest reliability of the BART has revealed a sound test re-test reliability of r = .66-.79, which suggests that this particular task is assessing a stable trait (Buelow & Barnhart, 2018; Weafer, Baggott, & De Wit, 2013; White et al., 2008; S. Xu, Korczykowski, Zhu, & Rao, 2013). However, other measures of impulsive decision making have not demonstrated such consistent results. Several studies have examined the test re-test reliability of the Iowa Gambling Task (IGT) and have yielded mixed results (r =.19- .58), suggesting that some behavioural measures may better reflect underlying impulsive traits than others (Buelow & Barnhart, 2018; Cardoso et al., 2010; Lejuez, Aklin, Jones, et al., 2003; Tuvblad et al., 2013; S. Xu et al., 2013).

6.1.3 Relationship between self-report and behavioural measures

Several meta-analyses have examined the relationship between self-report and behavioural measures of impulsivity, all of which have found that the two approaches do not correlate (Allom, Panetta, Mullan, & Hagger, 2016; King et al., 2014). Duckworth and Kern (2011) performed a meta-analysis of 236 studies to explore the convergent validity between various measures of impulsivity and self-control. The results revealed that the self-report measures of impulsivity correlated weakly with executive functioning tasks designed to measure self-control (such as the Stroop task and go/no-go task, r = .10). Duckworth and Kern (2011) also found that delayed gratification tasks (which are commonly used to measure impulsivity) correlated poorly with self-report measures of impulsivity (r = .15). Duckworth and Kern (2011) noted that their results were limited by the small number of studies that employed both self-report and behavioural measures (the exact number of studies was not reported). The majority of the research that Duckworth and Kern (2011) reviewed only included multiple self-report measures.

A meta-analysis by Cyders and Coskunpinar (2011) reviewed 27 studies that examined the relationship between self-report and behavioural measures of impulsivity. The authors compared the self-report and behavioural measures using previously reported underlying factor structures. They calculated how well the factors derived from the self-report measures correlated with the factors derived from the behavioural measures. For the self-report measures, the four factors proposed by Whiteside et al. (2005) in their UPPS scale were used. For the behavioural measures, the aforementioned five factor structure was used, which includes factors such as the inability to delay gratification, and being able to supress an automatic response. This factor structure has been applied in a number of previous studies (Dick et al., 2010). Small relationships were observed between the self-report and behavioural factors, ranging from r = .0006 - .151 with an overall correlation between the two methods of r = .097. These findings indicate the poor relationship between self-report and behavioural measures of impulsivity.

Sharma et al. (2014) conducted a meta-analysis to examine the relationships between measures of impulsivity. Like Cyders and Coskunpinar (2011), the authors compared self-report and behavioural measures based on the factors underlying performance on these measures. Sharma et al. (2014) used their own three factor structure for self-report measures. They derived their factor structure by performing a factor analysis on data gathered from 433 studies. They also derived their own four factor structure for the behavioural measures of impulsivity by factor analysing 98 studies. Building on previous research, Sharma et al. (2014) not only compared self-report and behavioural measures to each other, but also to impulsive 'daily life behaviours'. Based on the findings of the previous meta-analyses, the authors expected that the two methods would only weakly relate to each other. However, if both methods can predict whether people engage in impulsive behaviours, this would demonstrate that they are assessing separate constructs which independently predict engagement in impulsive behaviours. This would provide evidence for the ecological validity of each approach. As expected, the correlations between the behavioural factors and the self-report factors were small (r = .02). Nonetheless, both methods were able to predict small to moderate variance in a range of impulsive behaviours. Based on their results, Sharma et al. (2014) suggested that to achieve a valid assessment of impulsivity that relates to engagement in real-world impulsive

behaviours, it is sensible to employ both self-report and behavioural measures of impulsivity.

6.1.4 Reasons for the poor relationship

A number of explanations have been proposed for the lack of a relationship between self-report and behavioural measures of impulsivity. One possibility is that self-report measures are assessing impulsivity traits, while behavioural measures are capturing a person's state at the time of testing (Cyders & Coskunpinar, 2011). Sharma et al. (2014) supported this view, and suggested that behavioural tasks measure cognitive processes or abilities rather than traits. It would not, therefore, be expected that self-report and behavioural methods would correlate. Another consideration is that most impulsivity research has been conducted on the general population, which is a fairly homogenous sample (Sharma et al., 2014). The participants in previous studies are likely to be low in impulsivity, and may not vary enough in this regard to observe relationships between self-report and behavioural measures (Lane, Cherek, Rhoades, Pietras, & Tcheremissine, 2003; Sharma et al., 2014). It has been suggested that a stronger relationship between the two methods might be observed in populations that are more impulsive.

There may be methodological reasons underlying the lack of a relationship between self-report and behavioural measures. It has been argued that administering behavioural tasks in a controlled experimental setting is problematic, as they may not replicate the stress and affective aspects that would be present in real-world impulsive decisions. As such, these tasks do not properly capture impulsivity (Enticott & Ogloff, 2006; King et al., 2014). Another methodological reason for the lack of a relationship between self-report and behavioural measures concerns the parameters used for behavioural tasks, such as the rewards used in the tasks. Some studies offer actual rewards for task performance (e.g., money), whereas others use hypothetical rewards such as points (Lane et al., 2003). Differences in the rewards offered has been shown to affect task performance (Lane et al., 2003; Lansbergen, Schutter, & Kenemans, 2007). Such inconsistences makes comparisons between studies difficult (Sharma et al., 2014). Since most behavioural studies are small, their results often need to be aggregated to gain the statistical power to make meaningful comparisons, such as in the aforementioned meta-analyses. When the methodological approaches used for the behavioural tasks differs, it raises questions as to the validity

of aggregating results in this manner, and it makes it difficult to observe whether any true relationship exists between self-report and behavioural measures (King et al., 2014). These issues extend to the use of behavioural impulsivity tasks in PD research, as the parameters for behavioural tasks can differ significantly between studies (Evens et al., 2016), which makes it more difficult to determine how useful these tasks are for assessing impulsivity in PD.

6.1.5 Importance of the relationship

It is important to understand how self-report and behavioural measures relate to one another, and to understand how each might predict engagement in actual impulsive behaviours (Sharma et al., 2014). If these measures are assessing separate constructs, it is important that they are not referred to in a manner that suggests they are assessing the same outcomes (Cyders & Coskunpinar, 2011). This hinders impulsivity research in PD, as it confuses efforts to relate performance on these measures to outcomes of interest (e.g., pathological gambling, excessive shopping, risky behaviours; Cyders & Coskunpinar, 2011). Understanding how these measures might uniquely contribute to the assessment of impulsivity in PD is also important. Sharma et al. (2014) argued that while self-report and behavioural measures might not relate to each other, this is not necessarily a problem. These measures might separately predict engagement in impulsive behaviours by capturing an aspect of impulsivity that the other method cannot. Therefore, combining the two methods might provide the best predictive validity for a person's real-world impulsive behaviours (Cyders & Coskunpinar, 2011; Sharma et al., 2014). Determining if using a combination of both methods is the best means for assessing impulsivity in PD will assist the development of a comprehensive measure for those with PD.

The current study examines the relationship between self-report and behavioural measures of impulsivity in PD. Sharma et al. (2014) proposed that studies need to include populations with higher levels of impulsivity to investigate the relationship between self-report and behavioural measures. The participants in the present study were all diagnosed with PD, and were at an increased risk of impulsivity issues (compared to those without PD). Furthermore, it has been suggested that a latent score comprised of multiple behavioural impulsivity tasks might better capture the full scope of a person's impulsivity, and will therefore demonstrate a stronger relationship with self-reported assessments of impulsivity

(Duckworth & Kern, 2011; King et al., 2014). The present study used an overall latent score comprised of three behavioural measure of impulsivity in some of the analyses to examine the usefulness of this approach in PD. To comprehensively examine the utility of behavioural impulsivity tasks in PD, the aims of the current study are three-fold.

Part 1 of the study is an exploratory factor analysis of three behavioural impulsivity tasks (IGT, BART, and the Probabilistic Reward Task (PRT)) to examine how they may relate to one another. This will indicate whether the behavioural tasks are capturing similar or separate constructs. Past research has proposed that aggregating behavioural measures together may strengthen the relationship between self-report and behavioural measures (Duckworth & Kern, 2011; King et al., 2014). Behavioural measures are thought to be particularly susceptible to measurement error, due in part to the impact that a person's state can have on task performance (Duckworth & Kern, 2011). Using an overall latent score should reduce the impact that measurement error will have, as measurement errors in one task can be compensated for by the remaining tasks (Duckworth & Kern, 2011). Furthermore, research has suggested that different behavioural tasks might assess separate aspects of impulsivity. Therefore, while the tasks may not load onto a single factor, aggregating these measures could provide a more holistic objective assessment of impulsivity (Cyders & Coskunpinar, 2011). Furthermore, performance on the latter trials of the BART and IGT (used in the present study) has been shown to differ to earlier trials in some populations, and is thought to better reflect impulsive tendencies (Buelow & Barnhart, 2018; Dean, Sugar, Hellemann, & London, 2011). The exploratory factor analysis in the present study will help to determine whether this is also the case in PD.

Part 2 examines how well performance on the behavioural tasks relates to actual engagement in impulsive behaviours. Studies one and two have shown that self-report measures relate to the engagement in impulsive behaviours. Sharma et al. (2014) suggested that to be valid, behavioural tasks also need to relate to a person's engagement in impulsive behaviours. This study explores whether behavioural measures can identify people with PD who engage in problematic impulsive behaviours. Behavioural impulsivity tasks are commonly used in PD research, examining their validity for use in this area of research is therefore vital. If they are a valid measure, behavioural tasks could assist clinicians to identify people with PD

that are affected by impulsivity issues, which is crucial for implementing appropriate treatment strategies (Ramirez-Zamora et al., 2016).

6.2 Hypotheses

1. Each behavioural measure will display a significant weak positive relationship with engagement in impulsive behaviours (SERB).
2. An overall latent variable for the behavioural tasks will have a moderate significant relationship with the engagement in impulsive behaviours. This would demonstrate that using an overall latent variable for the three behavioural tasks is a more valid assessment of impulsivity than using each tasks individually.

Part 3 of the study examines the role of insight in the relationship between self-report measures of impulsivity and an overall latent score comprised three behavioural tasks (IGT, BART, and PRT). A number of PD studies have used objective behavioural tasks to assess the accuracy of self-reported abilities, by examining how well a person's self-reported abilities relate to their performance on objective tasks (Kudlicka et al., 2013; Lehrner et al., 2015). While this could be a useful approach to assess the accuracy of self-reported impulsivity in PD, it is well established that self-report and behavioural measures of impulsivity do not correlate well. However, it is possible that this relationship will be stronger for people who have better insight into their own impulsive behaviours. As discussed in chapter five, insight may impact a person's ability to self-report their own behaviours. In light of this, it was predicted that a person's level of insight will moderate the relationship between self-reported impulsivity and the overall latent behavioural score. When a person has a higher level of insight, there will be a stronger relationship between their self-reported impulsivity and how impulsively they perform on the behavioural tasks. Conversely, a weaker relationship will be observed for those with lower levels of insight. This would demonstrate that insight facilitates the accurate self-reporting of their own impulsive behaviours, and that this is congruent with how they perform on behavioural tasks. An overall latent behavioural score comprised of three behavioural tasks will be used as it should be more representative of impulsivity as a whole (King et al., 2014).

3. The behavioural tasks will demonstrate weak significant relationships with the self-report measures.
4. An overall latent score for the behavioural tasks will demonstrate a moderate significant relationship with the self-report measures.
5. Insight will moderate the relationship between self-reported impulsivity and the overall latent behavioural score, such that higher impulsivity will increase the relationship between the behavioural and self-report measures.

6.3 Part 1: Analyses

Mplus 7.4 was used to analyse the data. To examine how the behavioural tasks related to one another, an exploratory factory analysis was conducted. Each of the behavioural tasks consisted of a number of blocks of trials. The BART has 30 trials and is scored by summing the average number of pumps for the trials in which the balloon did not explode. The 30 trials are split into three blocks of 10, the higher the score for each block, the more impulsively the participant performed. The PRT consists of three blocks of 100 trials. For each block of trials a response bias is calculated, a positive response bias indicates a greater attraction to reward. The higher the bias, the greater the attraction to reward. For the IGT the participant's choice of safe decks minus the choice of risky decks is calculated. There are five blocks of 20 trials and a score is calculated for each block, these scores were reverse coded so that like the previous two tasks, higher scores indicated greater impulsivity. The scores for each block from all three tasks were entered into the exploratory factor analyses models.

An oblique Geomin rotation was used for the analysis. An oblique rotation was used as it would be expected that any resulting factors could correlate slightly, and this method of rotation generally provides more 'realistic' factor solutions than an orthogonal rotation (Schmitt, 2011). A Geomin rotation criterion was used as it has the ability to produce parsimonious solutions that are data driven, making it well suited to exploratory factor analyses (Hattori, Zhang, & Preacher, 2017). One to five factor solutions for the data were generated.

6.4 Part 1: Results

The descriptive statistics for the models are displayed in Table 6.1. The factor analysis models indicated that the three factor solution fit was the best fit. The model fit statistics indicated that the three factor solution fit the data well. The standardised root mean square residual was .059, the comparative fit index was .97, and the chi-square test of model fit was insignificant, all of which suggest good model fit (Hu & Bentler, 1999; Schermelleh-Engel, Moosbrugger, & Müller, 2003). The factor loadings for the behavioural task blocks are displayed in Table 6.2.

Table 6.1 Descriptive statistics for the behavioural tasks

Task	M(SD)	Range (Min – Max)
IGT	24.8 (16.0)	-21 – 53
PRT	.09 (.18)	-.36 – .46
BART	29.7 (15.0)	4.9 – 64.9
Overall Z-score	0 (.63)	-1.4 – 1.8

Table 6.2 Geomin rotated factor loadings for the behavioural task trials in the three factor solution.

	Factor		
Task/Trial	1	2	3
IGT Block			
1	0.13	-0.16	0.31*
2	0.19	0.15	-0.11
3	0.49*	0.02	0.04
4	0.60*	0.03	0.03
5	0.96*	-0.01	-0.06
PRT Block			
1	>0.01	-0.01	0.45*
2	>0.01	>0.01	1.04*
3	-0.06	0.08	0.42*
BART Block			
1	-0.12	0.83*	-0.03
2	0.05	0.96*	0.02
3	>0.01	0.86*	0.10

*$p < .05$

The results of the factor analysis confirm that the trial blocks of the behavioural tasks load onto their own task, with only a couple of exceptions. The first two trials of the IGT did not load onto the same factor as the last three trials. This is consistent with literature regarding the scoring of the IGT (Buelow & Barnhart, 2018; Gansler, Jerram, Vannorsdall, & Schretlen, 2011a). It is thought that participants are generally establishing which decks are safe or risky in the first two blocks of trials, which has led researchers to recommend using the last 60 trials (three blocks) of the IGT for the most valid assessment of impulsivity (Buelow & Barnhart, 2018; Gansler et al., 2011a). In contrast, all the blocks of trials for the BART loaded onto one factor, as did the blocks of trials for the PRT. The first block of the IGT loaded onto the PRT factor, but as the loading was somewhat low this was not considered to be an issue. These results confirm that the behavioural tasks load onto their own factors, and that only the latter three blocks of trials for the IGT should be used as a measure of impulsivity. As such, only the last three blocks of trials were used in the subsequent analyses.

6.5 Part 2: Analyses

To test hypotheses one and two and examine how the behavioural tasks relate to engagement in impulsive behaviours, two different models were used. The first model (see Figure 6.1) included each latent variable for the behavioural tasks independently covarying with the SERB. This examined whether any of the behavioural tasks independently related to engagement in risky behaviours. The second model (see Figure 6.2) included all of the behavioural tasks loading onto a single latent variable. This examined whether an overall latent score for the behavioural impulsivity tasks relates to the engagement in impulsive behaviours. Although the results of part one suggested that the behavioural tasks load onto separate factors, Cyders and Coskunpinar (2011) proposed that different behavioural tasks might capture differing *aspects* of impulsivity. Therefore, even though the tasks did not load onto a common factor, aggregating the tasks together could still provide a sound assessment of impulsivity.

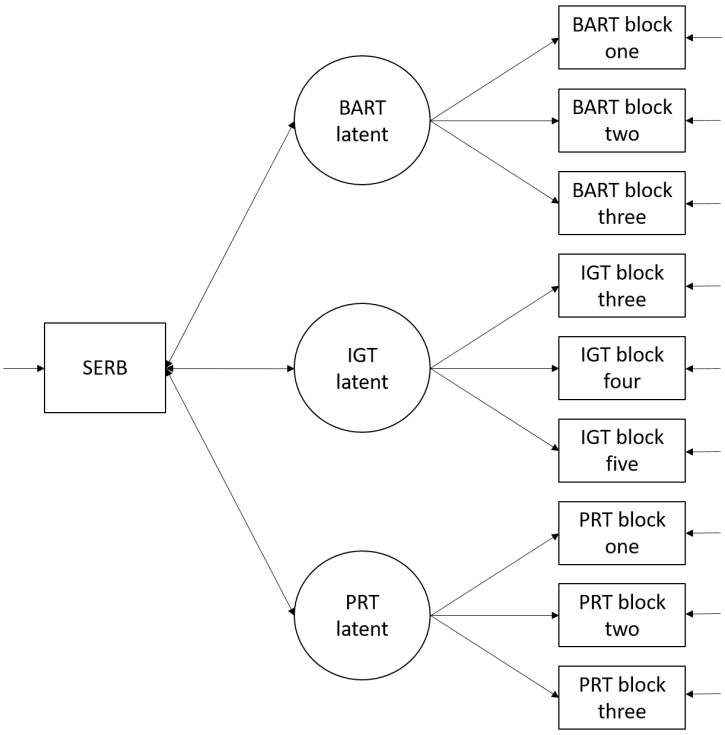

Figure 6.1 Diagram of model one. Latent variables were created for each behavioural task by regressing the relevant blocks of trials onto a latent variable. The latent variables for the behavioural tasks were covaried with the engagement in impulsive behaviours as assessed by the SERB.

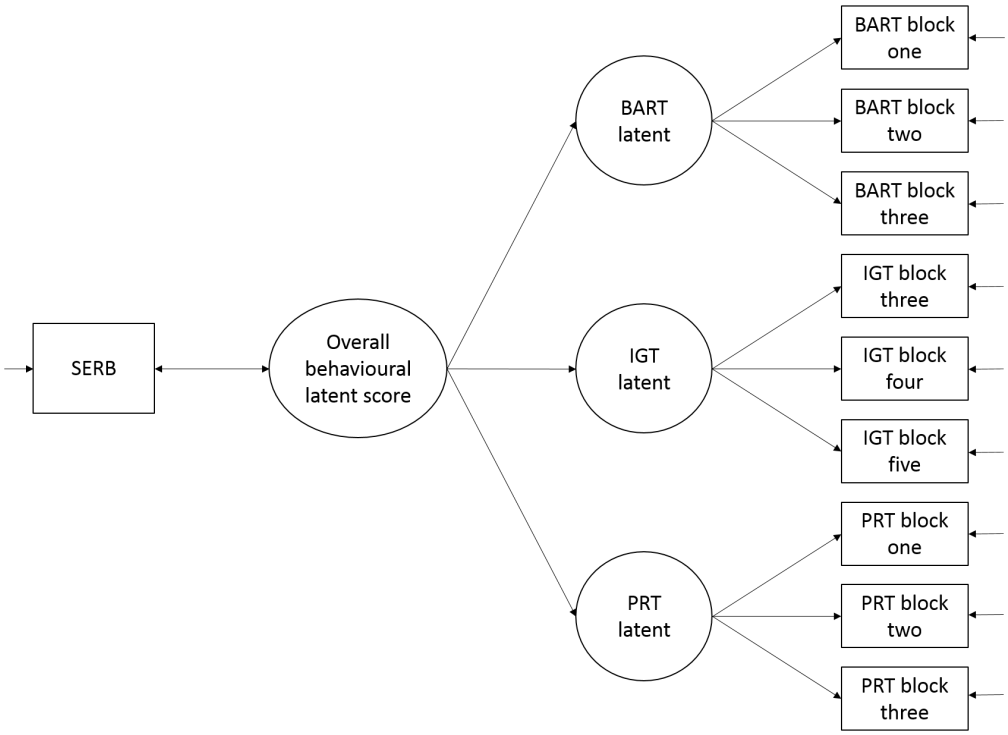

Figure 6.2 Diagram of model two. The latent variables for each behavioural task were regressed onto an overall latent behavioural variable. This overall latent behavioural score was covaried with the engagement in impulsive behaviours as assessed by the SERB.

6.6 Part 2: Results

The results of the two models are displayed in Table 6.3. The results indicated that neither the behavioural tasks in model one nor model two related to the engagement in impulsive behaviours.

Table 6.3 Relationship between behavioural tasks and engagement in impulsive behaviours. Standardised regression coefficients (β) are reported with standard errors in parentheses

	BART	IGT	PRT	Latent
		Model 1		Model 2
SERB	.097 (.126)	.079 (.136)	-035 (.152)	.099 (.679)

Note: No relationships reached significance. Latent refers to the latent variable created by aggregating the behavioural measures together.

6.7 Part 3: Analyses

Model three (see Figure 6.3) was used to test hypothesis three, examining whether each latent variable for the behavioural tasks covaried with each self-report measure of impulsivity (QUIP-RS, BAS Drive, BAS Fun, BAS Reward Responsiveness, BIS). A separate model was used for each of the self-report measures.

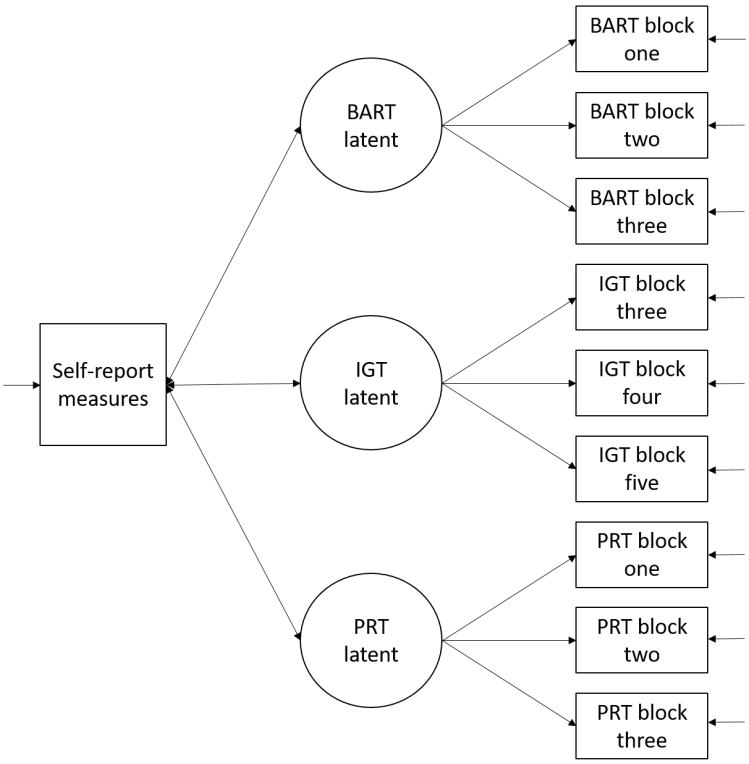

Figure 6.3 Diagram of model three. Latent variables for each behavioural task were covaried with the self-reported measures of impulsivity. Note: a separate model was run for each self-report measure of impulsivity (QUIP-RS, BAS Drive, BAS Fun, BAS Reward Responsiveness, BIS).

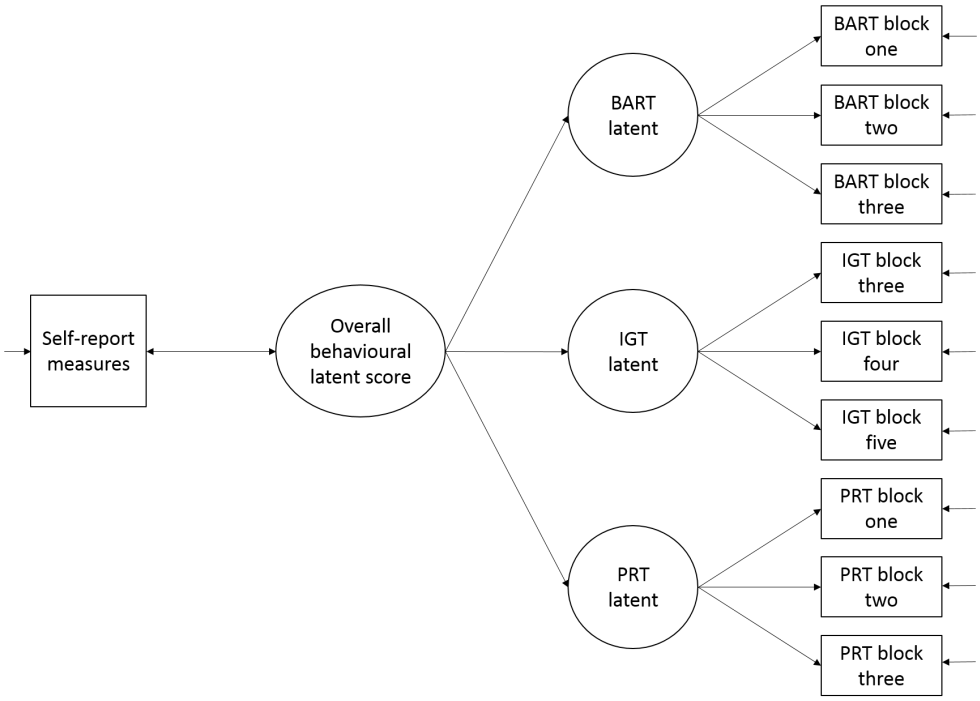

Figure 6.4 Diagram of model four. This overall latent behavioural score was covaried with the self-reported measures of impulsivity. Note: a separate model was run for each self-report measure of impulsivity (QUIP-RS, BAS Drive, BAS Fun, BAS Reward Responsiveness, BIS).

6.8 Part 3: Results

The results revealed that none of the self-report measures had a significant relationship with any of the behavioural tasks. Hypothesis four was tested by running model four (see Figure 6.4) to investigate whether the self-reported measures correlated with an overall latent variable for the behavioural tasks, again a separate model was used for each self-report measure of impulsivity. The results indicated that none of the self-report measures of impulsivity significantly correlated with the overall latent behavioural variable. The results of both models three and four are summarised in Table 6.4.

Table 6.4 Relationships between the behavioural tasks and self-reported measures of impulsivity. Standardised regression coefficients (β) are reported with standard errors in parentheses.

	BART	IGT	PRT	Latent
		Model 3		Model 4
BAS Drive	-.18 (.12)	.03 (.14)	-.17 (.14)	-.33 (.24)
BAS Fun	.04 (.12)	-.04 (.14)	-.21 (.14)	*
BAS Reward	.14 (.13)	-.21 (.14)	-.04 (.15)	*
BIS	-.12 (.13)	-.18 (.15)	-.23 (.14)	-.46 (.26)
QUIP	.06 (.13)	.18 (.13)	-.21 (.14)	*

Note: No relationships reached significance. Latent refers to the overall latent variable created by aggregating the behavioural measures together.
**Model would not converge in Mplus*

Although no significant relationship was observed between the self-report measures of impulsivity and the behavioural tasks, it is possible that a relationship may only exist between these two methods when a person has greater insight into their own behaviours. Hypothesis five was tested to examine whether the lack of relationship between the two methods is determined by the level of insight. Model five (see Figure 6.5) was conducted in Mplus to test whether insight acted as a moderator for the relationship between each self-report measure and an overall latent score for the behavioural tasks. A separate model was conducted for each self-report measures of impulsivity. Insight was measured using the Beck Cognitive Insight Scale (BCIS) discrepancy score. Interaction terms were created between the BCIS discrepancy score and each of the self-report measures to examine whether insight acted as a moderator. All of the models either failed to converge or the latent variable covariance matrix was not positive definite, as such these models could not be run in Mplus. By converting the scores of the behavioural tasks for each participant into z-scores, and combining these scores together, and overall Z score was calculated for the behavioural tasks. The overall behavioural Z score was used in model six (see Figure 6.6) to examine whether insight moderated the relationship between the self-report measures and the overall behavioural Z score. This eliminated the issues with the model not converging in Mplus. The results demonstrated that there was one significant interaction term between the QUIP-RS and the overall behavioural Z

score. Insight moderated the relationship between the QUIP-RS and the overall behavioural Z score. However, although the QUIP-RS had a moderate relationship with the behavioural Z-score (β = .37) this did not reach significance. Furthermore, the r^2 value was non-significant for the model, indicating that overall the QUIP-RS , BCIS discrepancy score, and the interaction term did not predict a significant amount of variance in the behavioural Z score (R^2 = .069, p = .25). The results of model six are summarised in Table 6.5.

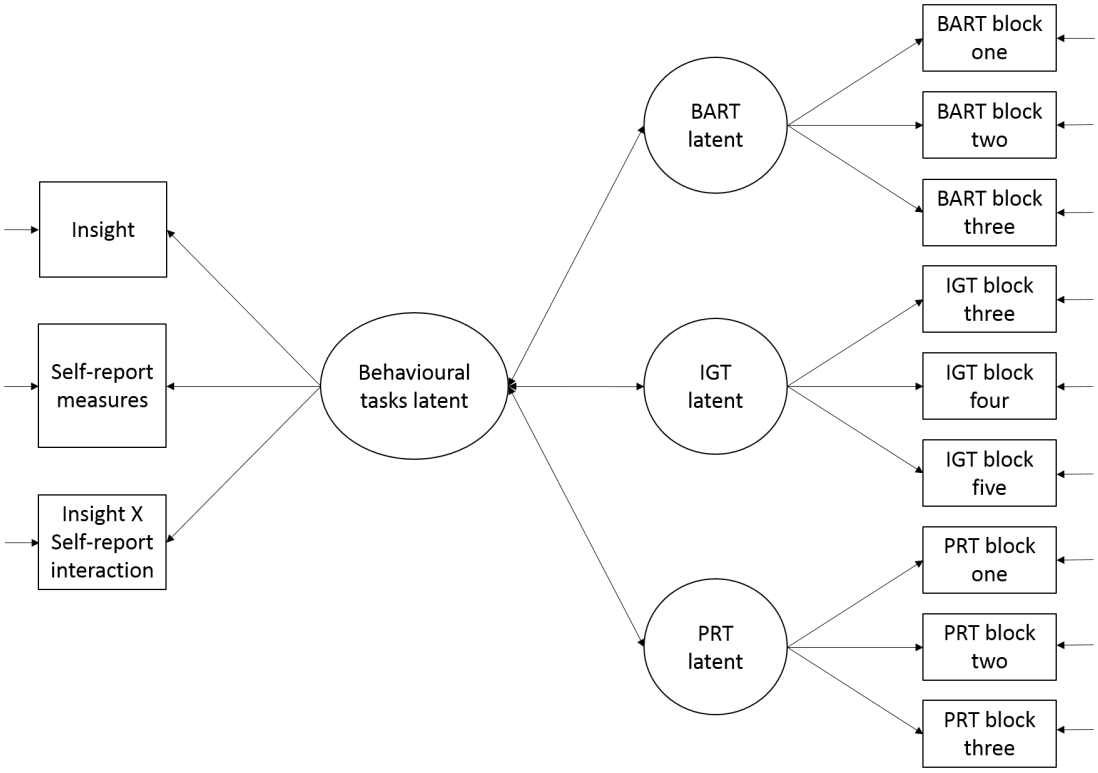

Figure 6.5 Diagram of model five. The overall latent behavioural score was regressed on the self-reported measures of impulsivity, the BCIS discrepancy score, and the interaction term. Note: a separate model was run for each self-report measure of impulsivity (QUIP-RS, BAS Drive, BAS Fun, BAS Reward Responsiveness, BIS).

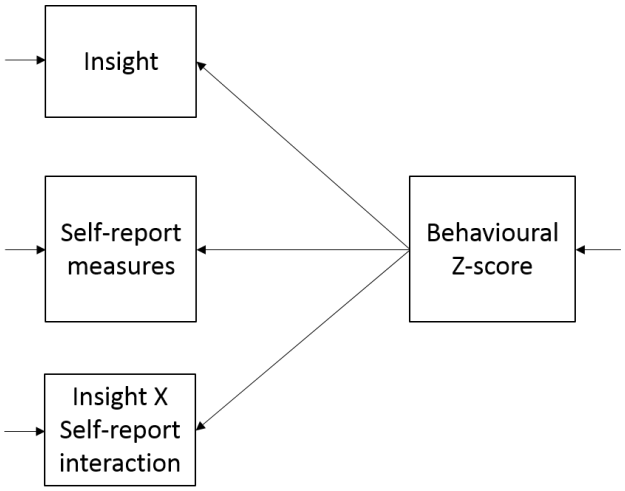

Figure 6.6 Diagram of model six. The overall Z-score for the behavioural tasks was regressed on the self-reported measures of impulsivity, the BCIS discrepancy score, and the interaction term. Note: a separate model was run for each self-report measure of impulsivity (QUIP-RS, BAS Drive, BAS Fun, BAS Reward Responsiveness, BIS).

Table 6.5 Overall behavioural Z-score regressed on each self-report measure of impulsivity, the BCIS discrepancy score, and the interaction term. Standardised regression coefficients (β) are reported with standard errors.

Beh Z score regressed on	β	SE
BAS Drive	-.19	.16
BCIS	-.10	.45
Interaction	.14	.74
BAS Fun	-.04	.16
BCIS	.30	.46
Interaction	-.29	.49
BAS Rew	.07	.21
BCIS	.40	.63
Interaction	-.41	.66
QUIP-RS	.37	.20
BCIS	.43*	.22
Interaction	-.63*	.28

**P <.05*

6.9 Discussion

Hypothesis one was not supported by the current results. There was no relationship between the behavioural tasks and engagement in 'real-world' impulsive behaviours. This is contrary to some previous research, which reported that behavioural tasks of impulsivity (including the tasks used in the present study) predict whether a person engages in impulsive behaviours (Buelow & Suhr, 2009; Lejuez, Aklin, Zvolensky, et al., 2003; Sharma et al., 2014). Hypothesis two was also not supported by the present results, there was no relationship between an overall latent score for the behavioural tasks and the engagement in risky behaviours. Previous research has suggested that aggregating behavioural tasks provides a more holistic measure of impulsivity, and could therefore improve the validity of behavioural impulsivity tasks (Cyders & Coskunpinar, 2011; King et al., 2014). Overall, these results cast doubt on the ecological validity of the use of behavioural measures of impulsivity in PD.

Hypotheses three and four were also not supported by the present results. This fits with previous research that has found that self-report and behavioural measures of impulsivity do not correlate well. Using an overall latent score for the behavioural tasks did not result in a significant relationship between these tasks and the self-report measures of impulsivity. This raises the question of whether aggregating the behavioural tasks into an overall score provides a more holistic measure of impulsivity. Lastly, hypothesis five was not supported by the current results. Only one of the BCIS discrepancy scores moderated the relationship between the self-reported measure (QUIP-RS) and the behavioural tasks. The interaction score for the Beck Cognitive Insight Scale and the QUIP-RS was significant, which indicates that insight moderates the relationship between the QUIP-RS and the overall Z score used for the behavioural tasks. However, the model overall did not predict a significant amount of variance in the behavioural Z score. Furthermore, when controlling for multiple comparisons, the interactions term was not significant. It is likely that observing an interaction term with a $p < .05$ reflects familywise error and is a consequence of running several models, rather than a true moderating effect being present. Based on the current findings, it is unlikely that insight moderates the relationship between behavioural and self-report impulsivity measures in PD.

6.9.1 Behavioural tasks and impulsive behaviours

No significant relationship was observed between the behavioural measures of impulsivity and impulsive behaviours as measured by the SERB. This was true for both the behavioural tasks individually and when they were aggregated into an overall latent score. For behavioural measures to be ecologically valid, they should relate to a person's engagement in 'real-world' impulsive behaviours. As Sharma et al. (2014) argued, if behavioural measures can predict a person's engagement in impulsive behaviours they have practical value. The present findings are at odds with previous research, as the behavioural measures employed in this study have previously demonstrated associations with real-world impulsive behaviours (in non PD populations).

The IGT used in this study is one of the most widely used tasks to assess impulsive decision making and has been associated with numerous impulsive outcomes such as alcohol use, gambling, and substance use (Buelow & Suhr, 2009; I. Kovács, Richman, Janka, Maraz, & Andó, 2017). The IGT was developed to capture impulsive decision making that characterises people with frontal impairments, which it has done successfully in a number of studies (Buelow & Suhr, 2009). The IGT has also been shown to predict both future substance abuse in clinical populations and current drug/alcohol abuse (Nejtek, Kaiser, Zhang, & Djokovic, 2013; Verdejo-Garcia et al., 2007). A recent meta-analysis by I. Kovács et al. (2017) found that people with gambling disorders and alcohol use disorders consistently performed worse on the IGT compared to healthy controls. Moreover, participants with intermittent explosive disorder (characterised by aggression and violence) perform more impulsively on the IGT, suggesting that performance on the task is also related to aggression (Best, Williams, & Coccaro, 2002). Given that the SERB examines many of these same behaviours (drug use, alcohol use, aggression, and gambling), it is unexpected that the present results demonstrated no relationship between the SERB and the IGT.

While a multitude of studies have linked performance on the IGT to real-world impulsive behaviours, this is not always the case. Like the present results, some researchers have not observed a relationship between the IGT and impulsive behaviours, meaning that the present findings are not at complete odds with the existing literature (Buelow & Suhr, 2009; Ursache & Raver, 2015). A review of the IGT by Buelow and Suhr (2009) concluded that research investigating the

relationship between the IGT and impulsive behaviours had mixed findings, which brings into question the ecological validity of the task. They proposed that the mixed results could be due to the affective state of the participant at the time of testing impacting upon performance on the task. Buelow and Suhr (2009) suggested that the test-re-test reliability of the IGT needed to be examined, as poor test re-rest reliability would indicate that the task is affected by a person's state at the time if testing. The reliability of the IGT has since been examined by several studies that have generally observed poor test re-rest reliability (Buelow & Barnhart, 2018). This does suggest that a person's mood could impact performance on the IGT and affect the validity of the measure, and could explain why the IGT did not relate to the engagement in impulsive behaviour in the present results.

Like the IGT, performance on the BART has been related to various impulsive behaviours and impulsive populations. Performance on the BART has been linked to the use of illicit drugs and alcohol (Fernie, Cole, Goudie, & Field, 2010; Hopko et al., 2006; MacPherson, Magidson, Reynolds, Kahler, & Lejuez, 2010). Adolescents with conduct disorder (associated with impulsive violent and socially inappropriate behaviours) perform worse on the BART (Crowley, Raymond, Mikulich-Gilbertson, Thompson, & Lejuez, 2006). Compared to the IGT, research linking the BART to real-world impulsive behaviours is less consistent. Mishra, Lalumière, and Williams (2010) failed to find an association between performance on the BART and gambling behaviours. The authors concluded that the results were unexpected, and proposed that there might be appealing aspects to gambling in the real-world that are not replicated by the BART.

Numerous studies have examined whether the BART can differentiate between people with and without substance abuse disorders, and have yielded conflicting results (Ashenhurst, Jentsch, & Ray, 2011; J. A. Campbell, Samartgis, & Crowe, 2013; Lauriola, Panno, Levin, & Lejuez, 2014). As discussed in chapter two, people with substance use disorders are generally more impulsive, and it would be expected that they would perform more impulsively on the BART. However, several studies have found opposing results (Ashenhurst et al., 2011; J. A. Campbell et al., 2013). A meta-analysis of the BART concluded that overall the task demonstrated a poor ability to discriminate between people with and without substance abuse disorders, which they suggested reflected the task's poor validity (Davis-Gahagen, 2014). Overall, the inconsistent relationship observed between the BART and

impulsive behaviours observed in past research and the present study, suggests that more research is needed to explore the validity of the BART for use in PD.

Research concerning the PRT is limited. The developers of the PRT claim that it is an objective measure of a person's attraction to reward (Pizzagalli et al., 2005). The task has been used to measure reward responsiveness across a range of clinical populations (Adkinson et al., 2018; Bogdan & Pizzagalli, 2006; Pizzagalli, Goetz, et al., 2008), including changes to reward responsiveness associated with the use of dopamine agonists (Pizzagalli, Evins, et al., 2008). This is particularly relevant to people with PD, as medications containing dopamine agonists are thought to contribute to impulsive behaviours in PD (Maréchal et al., 2015). In chapter two it was proposed that impulsivity can be conceptualised as an over-attraction to reward, and it would be expected that impulsive individuals might exhibit a stronger attraction to reward on the PRT. However, the results of this study did not demonstrate a relationship between the PRT and the engagement in impulsive behaviours. It is possible that more impulsive people do not have a greater attraction to reward. Alternatively, the PRT did not capture attraction to reward in the current PD sample. Future research should further evaluate whether the PRT is suitable for measuring attraction to reward in PD.

The results of the current study suggest that the behavioural tasks do not demonstrate ecological validity, as they did not show any association with the impulsive behaviours in the SERB. This is despite larger meta-analyses such as that done by Sharma et al. (2014) finding a significant (albeit small) relationship between the behavioural tasks and impulsive behaviours. A possible explanation is that the sample size resulted in the present study being under-powered, and was therefore unable to detect the typically weak relationship that is observed between behavioural tasks and engagement in impulsive behaviours. Consistent with this, the β values observed between the behavioural tasks and impulsive behaviours in the present study were very small. The behavioural tasks used in this study may not suitable for use in the PD population, and that is why no relationship was observed. Nonetheless, the IGT task has been used extensively in PD. A meta-analysis by concluded that people with PD on dopaminergic medication consistently perform worse on the IGT compared to healthy controls. This suggests that the IGT can capture some aspect of altered decision making that is present in PD but not healthy controls. However, a couple of studies have failed to find any differences in IGT performance for people

with PD and an ICD compared to people with PD and no ICD (Bentivoglio, Baldonero, Ricciardi, De Nigris, & Daniele, 2013; Biars et al., 2018). These findings suggest that IGT might not capture differences in impulsivity between people with PD, which was the aim of using the IGT in the present study (Biars et al., 2018).

The BART has been used in PD research, but to a lesser extent than the IGT. Simioni, Dagher, and Fellows (2012) used the BART to investigate impulsivity in PD and found that people with PD performed more impulsively in the latter trials of the task than healthy controls (Simioni et al., 2012). Claassen et al. (2011) explored how dopamine agonists contribute to impulsivity in PD using the BART. The results suggested that when PD participants abstained from dopamine agonists they performed less impulsively on the BART. Buelow, Frakey, Grace, and Friedman (2014) used both the BART and the IGT to compare people with PD to healthy controls. PD participants only performed more impulsively on the IGT, suggesting like the present findings, that the BART may not always capture impulsivity in PD. Overall, both the BART and the IGT have been used in numerous PD studies, a number of which have found that people with PD perform poorly on these tasks compared to healthy controls. This would indicate that these tasks are suitable for capturing an aspect of impaired decision making in PD. Whether these differences in decision making reflect increased impulsivity in PD remains unclear.

Another possible explanation for the lack of relationship between the behavioural tasks and impulsive behaviours is the 'broken leg phenomenon', which was first described by Meehl (1956). Meehl (1956) argued that whilst psychological measures can indicate that a person is more likely to engage in a certain behaviour, numerous other factors determine if the person will actually engage that behaviour. External factors may prevent people who are inclined to engage in a behaviour from actually participating in that behaviour (Grove & Lloyd, 2006), which could be particularly relevant to PD. The loss of independence in PD is well documented (Macleod, Grieve, & Counsell, 2016). A recent longitudinal study found that five years after diagnosis, 41% of people with PD had lost their independence (Bjornestad, Tysnes, Larsen, & Alves, 2016). In PD research the loss of independence is typically defined as an inability to independently complete 'activities of daily living' (Macleod et al., 2016). Activities of daily living include the ability to complete everyday tasks such as household chores, getting dressed, and eating (Macleod et al., 2016). If people with PD experience a loss of independence to

complete everyday tasks, it may be that some impulsive people with PD lack the means to engage in impulsive behaviours. Such individuals may then perform impulsively on a behavioural task, but cannot actually engage in impulsive behaviours in the real-world. A limitation to this explanation is that in chapters four and five, there was a relationship between self-reported and behavioural impulsivity. The self-report measures do not seem to have been affected by the broken leg phenomenon.

It is possible that the behavioural tasks do not measure stable impulsive behavioural traits, but measure the person's state at the time the task was administered. Impulsivity traits are said to underlie a person's tendency to engage in impulsive behaviours, and may therefore predict whether a person will engage in these behaviours over time (Carver, 2005; King et al., 2014). Behavioural tasks are thought to measure cognitive processes that relate to personality traits, and as such, should relate to a person's engagement in impulsive behaviours (Sharma et al., 2014). However, as a number of comprehensive reviews have suggested, behavioural tasks might capture states that fluctuate over time rather than stable traits (Cyders & Coskunpinar, 2011; Sharma et al., 2014). Scores on these tasks may not relate to actual impulsive behaviours as they capture a person's condition at the time of testing rather than their general behavioural tendencies (King et al., 2014).

As has already been discussed, behavioural tasks might not replicate the conditions experienced when making a decision in the real-world, which limits their ecological validity (Enticott & Ogloff, 2006). Impulsive decisions are likely to involve a degree of stress and affective states that may not be present when completing an behavioural task (King et al., 2014). The observed behaviours may only be relevant to that particular 'artificial' situation, and are not generalisable beyond the laboratory setting (Enticott & Ogloff, 2006; King et al., 2014). Potential issues with using hypothetical rewards in behavioural tasks were also previously mentioned. Due to ethical considerations, the present study offered hypothetical rewards for performance on the behavioural tasks. It remains unclear as to whether offering real rather than hypothetical rewards affects task performance (Bowman & Turnbull, 2003; Lane et al., 2003). It is conceivable that use of hypothetical rewards could have contributed to the behavioural tasks not relating to the real-world impulsive behaviours in the present study. Future research should examine whether

performance on these tasks for people with PD is affected by the nature of the rewards offered.

6.9.2 The validity of behavioural impulsivity tasks in PD

The present results suggest that the behavioural tasks used in this study lack ecological validity, which has implications for previous PD studies that have used these tasks. Past research may have erroneously concluded that performance on these tasks in PD is indicative of impulsivity. A multitude of different PD studies have used the IGT and the BART. A meta-analysis by Evens et al. (2016) identified 25 studies that compared the IGT performance of people with PD to healthy controls, and found that people with PD consistently performed worse. Evens et al. (2016) and many of the studies included in their review inferred the observed impaired performance on the IGT reflects increased impulsivity in PD. Some of the reviewed studies even suggest that the poor performance on the IGT could reflect the presence of ICDs. Castrioto et al. (2015) found that participants who reduced their dopaminergic medication following deep brain stimulation performed less impulsively on the IGT. Based on these findings, they concluded that dopaminergic medication in PD contributes towards ICDs. Similar studies have used the BART for the same purpose (Claassen et al., 2011; Simioni et al., 2012). These studies generally assume that performance on these tasks is related to impulsivity in PD, and reflects how impulsively a PD participant will behave in the real-world. Even though these tasks have been related to 'real-world' impulsive behaviours in the general population, it might be inappropriate to assume that performance on these tasks for people with PD also relates to engagement in impulsive behaviours.

Performance on the tasks used in this study and past research might reflect differences in terms of decision making in PD, and might not necessarily reflect differences in impulsivity. Behavioural tasks suffer from 'impurity issues', as they concurrently capture performance across several different cognitive domains (Enticott & Ogloff, 2006). For example, it has been argued that performance on the IGT reflects executive functioning ability rather than impulsivity (Gansler, Jerram, Vannorsdall, & Schretlen, 2011b). The differences observed in PD research on behavioural impulsivity tasks might not reflect differences in impulsivity, but rather differences in other cognitive domains such as executive functioning. Evens et al. (2016) observed that healthy controls consistency outperformed people with PD on

the IGT, but this may have been due to the IGT capturing differences in executive functioning. People with PD are known to have impaired executive functioning compared to healthy people (Kudlicka et al., 2011). The poorer scores observed for people with PD could reflect task impurity and be due to the IGT capturing impaired executive functioning in PD. Consistent with this explanation, Bentivoglio et al. (2013), compared the performance of people with PD and an ICD to those without an ICD on the IGT. Importantly, while the participants with an ICD were clinically diagnosed as being more impulsive, they were matched with the control PD participants in terms of overall cognitive ability. This was reflected in the results, as the ICD group performed similarly to the control group on several measures of executive functioning, indicating that the groups did not differ in this aspect. Bentivoglio et al. (2013) also found that the two groups did not differ in term of their performance on the IGT. Therefore, the groups' performance on the IGT likely reflected their similarities in terms of executive functioning, rather than their clinical differences in terms of engagement in impulsive behaviours.

6.9.3 The lack of relationship between behavioural and self-report measures of impulsivity

Despite employing a number of recommended strategies to try and improve the typically weak relationship between behavioural tasks and self-reported impulsivity, the present findings are in line with a number of comprehensive studies that have shown a weak relationship between the two (Cyders & Coskunpinar, 2011; Duckworth & Kern, 2011; Sharma et al., 2014). The results demonstrate that an aggregated Z-score for the behavioural tasks did not have a significant relationship with any of the self-reported measures of impulsivity. Furthermore, using a more impulsive sample rather than a homogenous one (47% of the sample met the criteria for an ICD according to the QUIP-RS) did not improve this relationship. It was also predicted that the poor relationship between the self-report and behavioural methods could be moderated by insight, but this was not supported by the results.

6.9.4 Limitations

The present study had several limitations. Examining whether the behavioural tasks could predict engagement in risky behaviours depends on the SERB being a valid measure of risky behaviours in PD. As suggested in chapter four (study one),

the SERB comprises previously established measures, which should minimise concerns regarding the measure's ability to capture the PD participants' engagement in impulsive behaviours. Furthermore, the behavioural tasks did not relate to the QUIP-RS which screens for the presence of clinically problematic impulsive behaviours, or the BIS/BAS scale which examines attraction to reward and fear of punishment. Therefore, the results would suggest that the observed inability of the behavioural tasks to predict engagement in impulsive behaviours is due to the behavioural tasks not capturing trait impulsivity rather than the SERB not being valid for use in PD.

6.9.5 Significance

The lack of a relationship between the behavioural and self-report measures supports the notion that they are capturing separate constructs (King et al., 2014). The behavioural tasks did not relate to the engagement in impulsive behaviours, self-reported impulsivity, or ICD severity (QUIP-RS). In studies one and two, the self-report measures demonstrated a moderate relationship with engagement in real-world impulsive behaviours, whereas the behavioural tasks have not indicated a relationship with any of the other measures. These results are congruent with a position taken by multiple researchers; that self-report measures capture impulsive traits, and behavioural tasks capture a person's state at the time of testing (Cyders & Coskunpinar, 2011; King et al., 2014; Sharma et al., 2014). Regardless of what the behavioural tasks used in this study might be capturing, the present results bring in to question their ability to operationalise impulsivity in PD.

The lack of a relationship with the attraction to reward and fear of punishment (BIS/BAS scale) also suggests that the behavioural tasks used do not relate to this conceptualisation of impulsivity. This is despite the PRT being explicitly designed to objectively assess attraction to reward (Pizzagalli et al., 2005). As discussed in chapter two, attraction to reward and fear of punishment can be considered fundamental underpinnings of impulsivity as a construct, therefore the lack of relationship with the factors assessed by BIS/BAS scale further brings into question the utility of behavioural impulsivity tasks in PD.

Future research should be cautious about using behavioural tasks to assess impulsivity in PD. The validity of these measures in PD needs to be further evaluated before inferences regarding impulsivity can be made based on these tasks, which is

concerning given the numerous PD studies that have already used these tasks to examine impulsive tendencies (Claassen et al., 2011; Evens et al., 2016; Simioni et al., 2012). As PD is associated with a number of functional changes in the brain (inducing changes to reward and decision making systems), it may be presumptuous to assume that these measures are capturing the same constructs in people with PD as they are in the general population. The present findings are not sufficient to dispute the conclusions of past research in PD that have used behavioural impulsivity tasks, nor are they enough to dismiss the utility of these tasks in PD research. However, the conclusions of research that has employed behavioural measures of impulsivity in PD should be treated with a degree of caution until these measures are more thoroughly evaluated. Future research needs to decipher what behavioural measures of impulsivity actually assess to determine the usefulness of these measures for future research and clinical practice. Additionally, alternative methods for overcoming the issues with self-reporting impulsivity need to be explored. While the behavioural tasks have not demonstrated the ability to predict engagement in risky behaviour in the present study, self-report measures still have several limitations which make depending on this method of assessment alone problematic.

Chapter 7 Study 4: Nominated informant appraisals for assessing impulsivity in PD

7.1 Introduction

The findings of chapter five, study two, suggest that contrary to expectations, insight may not be impaired in the present sample. However, a review of research examining insight in PD concluded that people with PD generally have reduced insight into their own behaviours (Bloomfield et al., 2016). This is thought to contribute to the under-reporting of impulsive behaviours in PD, as people with PD may not recognise that they are engaging in problematic impulsive behaviours (Weintraub et al., 2015). Furthermore, people with PD may avoid disclosing their impulsive behaviours due to embarrassment (Weintraub et al., 2010). Chapter six, study three, illustrated that using behavioural measures to provide an objective assessment of impulsivity in PD could be troublesome. An alternative method that had been proposed to help the limitations of self-reporting impulsive behaviours in PD is to ask peers of people with PD to provide an appraisal on the impulsive behaviours of people with PD (Baumann-Vogel et al., 2015). Informants (i.e., friends and family of people with PD) have the advantage of being able to provide information that is not dependent on the insight of the person with PD (Lanni et al., 2014). Ramirez-Zamora et al. (2016) argued that because informants represent such a valuable source of information regarding the impulsive behaviours of people with PD, future clinical practice should routinely involve informants in the assessment and treatment of these behaviours.

Two methods are primarily used to investigate the validity of self-reported assessments in PD. The first approach is to compare self-reported abilities with performance on objective behavioural measures (Kudlicka et al., 2013). This method is dependent on the behavioural measures being valid for use in PD (Lanni et al., 2014). The results of chapter six, study three, demonstrated the use of behavioural impulsivity tasks in PD may be problematic. The second approach is to compare self-reported behaviours to a proxy's assessment, such as a nominated informant or a clinician. Research employing this strategy assumes that informants represent a 'gold standard' for reporting a person's abilities, and that their appraisal is valid (Bloomfield et al., 2016; Mack et al., 2013). Any difference between the PD

participant's self-reported assessment and the proxy's assessment is attributed to deficits in the ability to self-report accurately (Bloomfield et al., 2016). This second approach has been used by numerous studies to examine whether people with PD can accurately report their own abilities across a range of different tasks (McKinlay et al., 2008).

7.1.1 Informants in PD assessments

There are some issues with assuming that informants are a gold standard of information. An informant's assessment of someone with PD is their subjective opinion and is therefore vulnerable to biases (McKinlay et al., 2008). Informants have been found to over-report instances of some issues in PD such as depression, while under-reporting other disorders like anxiety (Kua et al., 2018). Informants are often involved in caring for the person with PD and research has shown that the higher the informant's perceived 'burden of care' is, the more their ratings differ from that of the person with PD (Schiehser et al., 2013). Moreover, higher self-reported depression by the informants has been shown to affect their appraisals of people with PD (Schiehser et al., 2013). It has been demonstrated that if the informant is more depressed, they are more likely to view the PD participant's behaviour in a negative manner (McKinlay et al., 2008). These findings demonstrate that an informant's assessment of someone with PD might not be a valid interpretation of their true abilities/behaviours. Numerous studies have critically examined the appropriateness of using informants to assess the abilities of people with PD in several domains, such as memory, executive functioning, and apathy.

Naismith, Pereira, Shine, and Lewis (2010) investigated the relationship between an informants' appraisal of PD participants' cognitive ability, and how the PD participants performed on objective behavioural tasks. The PD participants were required to complete a series of behavioural tasks that examined a range of cognitive domains, including working memory, executive function, verbal memory, and psychomotor speed. Based on their performance on the behavioural tasks, some PD participants were identified as having mild cognitive impairment. The informants completed questionnaires which required them to judge whether the person with PD exhibited issues relating to their memory, mood, and everyday skills. PD participants that were identified as having mild cognitive impairment were correspondingly identified as having significantly more cognitive issues by their informants,

compared to the participants without mild cognitive impairment. These results suggest that the informants were able to successfully evaluate and report on the cognitive status of the PD participants. Informants could, therefore, provide a useful assessment of impulsivity in PD.

Memory

Woods and Kneebone (2016) examined whether an informant's appraisal of a PD participant's memory difficulties related to the PD participant's performance on memory tasks. The PD participants also self-reported whether they experienced any issues with their memory. The results demonstrated that the PD participants who reported experiencing more memory difficulties correspondingly performed poorly on the memory tasks. The informants also reported more memory difficulties for the PD participants who struggled with the memory tasks. The authors concluded that both the participants and their informants were sensitive to detecting and reporting memory difficulties resulting from PD.

Woods and Kneebone (2016) unexpectedly found that the PD participants who performed within normal levels on the memory tasks generally rated their own memory as being significantly worse than their informants did. The authors reasoned that people with PD may be more aware of subtle changes in their memory which are not observable to an informant, and so rated their memory as being poor compared to their informant's appraisal. However, an alternative explanation for these findings is that the PD participants overestimated their memory difficulties. Bloomfield et al. (2016) reviewed research that examined self-awareness of memory impairments in PD. They suggested that people with PD and intact cognitive abilities could be hypersensitive to changes in their memory, leading these people overestimate their memory issues. It seems reasonable to suggest that the results of Woods and Kneebone (2016) reflect the informants' ability to accurately report less memory issues for the participants that performed within normal levels on the memory tasks, and a tendency for the PD participants with normal memory abilities to overestimate their memory issues. It could be problematic for examining impulsivity in PD, if some people with PD similarly over-estimate their impulsive tendencies.

Apathy

Several studies have explored the use of nominated informants for assessing apathy in PD. Valentino et al. (2018) compared PD participant's self-reported levels apathy to their informant's assessment of their apathy. The results revealed that the

PD participants self-reported significantly higher levels of apathy compared to the informants. To understand whether the self-report or informant's appraisal was more accurate, Valentino et al. (2018) examined how well the assessments of apathy correlated with an assessment of executive functioning. Apathy in PD is consistently associated with lower levels of executive functioning (den Brok Melina et al., 2015), therefore, an accurate appraisal of apathy in PD is likely to be negatively correlated with executive functioning scores. Only the PD participants' self-reported apathy displayed a significant negative relationship with the executive functioning task scores. Valentino et al. (2018) concluded that when assessing apathy, self-reporting is the best means of measurement. Such findings indicate that informants are not always a valid source of information and questions the assumption that they are a 'gold standard of information.

A couple of studies investigating the utility of informants for assessing apathy in PD have been more supportive of their use. As apathy in PD is associated with lower executive functioning, Fitts et al. (2015) wanted to see if an informant's appraisal of the PD participant's apathy would predict the PD participant's likelihood of developing dementia later on. The results indicated that the participants who were identified as being apathetic by informants at baseline were significantly more likely to have developed dementia three years later. Fitts et al. (2015) concluded that the informant's assessment of apathy demonstrated validity for predicting the likelihood of developing dementia. Radakovic, Davenport, Starr John, and Abrahams (2017) also supported the use of informants for assessing apathy in PD. They found that outcomes related to apathy such as depression, had stronger correlations with the nominated informants' apathy ratings than self-reported apathy. The authors argued that this demonstrates the advantage of using nominated informants over self-reported assessments for examining apathy in PD.

While studies comparing self-reported and informant appraisal of apathy have yielded mixed results, a systematic review of apathy prevalence in PD found that studies employing self-report methods consistently reported apathy rates 8% higher than studies using nominated informants or clinicians (43% vs. 35% respectively; den Brok Melina et al., 2015). This suggests that like memory abilities, people with PD could overestimate their difficulties concerning apathy.

Executive functioning

The efficacy of using nominated informants to evaluate executive functioning in PD has also been explored. Lanni et al. (2014) examined whether self-reported or informant reported executive functioning ability best related to the PD participant's performance on behavioural executive functioning tasks. Despite the PD participants completing several executive functioning tasks, both self and informant reported executive functioning only demonstrated a significant relationship with one task (designed to measure processing speed). The authors reasoned that the behavioural tasks could have lacked validity, and therefore failed to reflect changes in 'real-world behaviours' that would be noticed by the informants and the PD participants.

The results of Lanni et al. (2014) also revealed that like self-reported issues with memory and apathy, the PD participants reported that they had significantly poorer executive functioning compared to their informants. Lanni et al. (2014) proposed several possible explanations as to why self-reported executive functioning was consistently lower than the informant ratings. The authors suggested that informants may not be able to detect subtle changes in executive functioning that are apparent to the person with PD, as these changes may not yet be obvious to an external viewer. They also proposed that due to the heightened depression that was observed in the PD group, they may have been more likely to overstate their difficulties with executive functioning. Lastly, Lanni et al. (2014) put forward that impaired executive functioning may limit how accurately the PD participants could self-report their own executive functioning ability. However, as the objective tasks did not correlate well with either the self or informant reported executive ability, it is difficult to decipher which explanation is the most correct.

Kudlicka et al. (2013) conducted a similar study to investigate whether people with PD are aware of their executive functioning deficits. PD participants and their informants completed a questionnaire which examined whether a person had issues with executive functioning abilities (e.g., sustaining attention). The PD participants also completed several behavioural executive functioning tasks. Overall, the ratings of executive functioning ability did not differ between the informants and the PD participants. However, the PD participants with intact executive functions as determined by their performance on the behavioural tasks self-reported significantly more executive functioning difficulties than their informants did. Again, this may

illustrate the tendency of people with PD to overestimate their impairments when their abilities are still relatively intact.

7.1.2 Summary of nominated informant research in PD

In terms of self-reporting, several studies suggest that people with PD and relatively intact abilities may be hypersensitive to any changes that could result from their PD, and are therefore inclined to overestimate their impairments. These studies also demonstrate that research investigating the use of informants has yielded mixed results. Some results suggest that self-reported appraisals are more valid than informants (Valentino et al., 2018). Nevertheless, several studies have found that interpretations provided by informants related to the PD participants' performance on objective behavioural tasks (Naismith et al., 2010; Woods & Kneebone, 2016). Whether this demonstrates the usefulness of informants depends on the behavioural tasks being valid (Lanni et al., 2014).

Overall, despite the difficulties that exist in trying to determine whether appraisals provided by PD participants or their informants best reflect the true nature of a situation, these studies illustrate that informants have the potential to be a useful source of information. Therefore, when dealing with the assessment of impulsive behaviours, informants could provide a crucial means to identify people with PD that have issues with impulsivity and require assistance. Especially given people with PD may be inclined to hide their impulsive behaviours from clinicians due to their personal and potentially embarrassing/incriminating nature (Weintraub et al., 2015).

7.1.3 Nominated informants in PD impulsivity research

As discussed in chapter five, Baumann-Vogel et al. (2015) demonstrated that informants reported significantly more issues with impulsive behaviours than the PD participants self-reported, suggesting that the person with PD underestimated their difficulties concerning impulsivity. This is contrary to the tendency for the PD participants to overestimate their difficulties. This could indicate that for impulsive behaviours, PD participants are underestimating the true extent of their impulsiveness. A limitation of this study is that Baumann-Vogel et al. (2015) used their own screening measure created to identify ICDs, which has not yet been validated for use in PD. However, a couple of studies have also examined

informants' reporting of impulsive behaviours using the more established Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease (QUIP).

Ricciardi et al. (2016) compared informant and PD participant ratings on the QUIP. The results revealed that 57% of the informants had poor levels of agreement compared to the person with PD (defined by the authors as a Cohen's Kappa below 0.41). PD participants were more likely to self-report clinically significant hypersexuality, punding behaviours, and dopamine dysregulation syndrome, whereas the informants reported more ICD positives for pathological gambling, and compulsive buying/eating. The authors concluded that PD participants and their informants can significantly differ in their interpretations regarding excessive impulsive behaviours.

A larger study by Papay et al. (2011) had 71 participants and their informants complete the QUIP to examine their agreement on the presence of ICDs. The PD participants also completed a diagnostic interview as a clinical means to identify whether they had an ICD. The inter-rater agreement between the PD participant's and informants was assessed using Cohen's kappa, which indicated a moderate agreement between the two ($\kappa = .41$). All nine participants who had an ICD according to the diagnostic interview were also identified as having an ICD by both the PD participants' and their informants' responses to the QUIP. As discussed previously, because the QUIP is a screening measure it does suffer from false positives. Only a third of positive identifications according to the QUIP were confirmed by the diagnostic interview, suggesting that the QUIP can be prone to false positives. Based on this, Papay et al. (2011) suggested including informants when administering the QUIP and if either the person with PD or their nominated informant did not indicate that a particular ICD is present, then that ICD can be ruled out for that person.

7.1.4 Present study

Previous research has investigated the agreement between people with PD and their nominated informant in terms of impulsive behaviours. The present study compares PD participant and informant responses to the QUIP-RS to examine which best relates to the PD participant's engagement in impulsive behaviours. Rather than assuming that informants represent a gold standard assessment of impulsivity, the present study will explore which source of information best relates to engagement in

impulsive behaviours (as measured by the self-reported SERB). While the results discussed in chapter six (study three) suggest that insight may not be impaired in the present sample, scores on the Beck Cognitive Insight Scale can differ significantly between different clinical populations (Penney et al., 2018). As such, the findings that the sample's scores were comparable to normative data does not necessarily mean that insight is not somewhat impaired in the present sample. Due to potential issues with insight in PD, possible motivations to hide impulsive behaviours, and the chance that people with PD are hypertensive to physical and cognitive changes resulting from PD, it is anticipated that nominated informants will be the more valid source of information regarding impulsive behaviours. The QUIP-RS was used as the measure of impulsivity, as research comparing self and informant reported impulsivity has primarily used this measure. Furthermore, the QUIP-RS was observed to have the strongest relationship with impulsive behaviours in chapter four.

7.2 Hypotheses

1. Each ICD assessed by the QUIP-RS will demonstrate fair to moderate Cohen's Kappa values, indicating a reasonable level of agreement between the informants and PD participants reporting.

To test hypotheses two and three, a discrepancy score was calculated by subtracting the informants QUIP-RS score from the PD participants QUIP-RS score. A larger discrepancy score is indicative of a greater disagreement between the PD participant and the informant.

2. A higher discrepancy score will increase the relationship between nominated informant reported impulsivity and the engagement in impulsive behaviours. This would suggest that when the nominated informant and the person with PD disagree, the nominated informant report of impulsivity more accurately reflects reported risky behaviours for the SERB.
3. A higher discrepancy score will decrease the relationship between self-reported impulsivity and the engagement in impulsive behaviours. This

suggests that when the nominated informant and the person with PD disagree, self-reported impulsivity less accurately reflects reported risky behaviours for the SERB.

7.3 Analyses

To test hypothesis one, Cohen's Kappa tests were conducted using SPSS version 24. Mplus version 7.4 was used to test the models for hypothesis two and three (see Figure 7.1 and Figure 7.2).

7.4 Results

Table 7.1 displays the descriptive statistics for the ICDs examined by the QUIP-RS for both PD participants and nominated informants. The Cohen's Kappa values indicated that the agreement between self-reported and the informant-reported ICDs on the QUIP-RS varied substantially from .08 to .68. Table 7.2 compares the Cohen's Kappa values from the present study to those reported Papay et al. (2011). Levels of agreement for gambling and sexual ICDs were moderate across both studies, whereas levels of agreement on buying, eating, and punding/hobbyism were generally lower.

Table 7.1 Descriptive statistics for ICDs examined by the QUIP-RS comparing PD participants to nominated informants

ICD	PD Participant M (SD)	Nominated informant M (SD)	*p* value^
Gambling	0.81 (1.56)	1.33 (2.74)	.023*
Sex	3.27 (3.05)	2.87 (3.06)	.174
Buying	2.44 (2.73)	2.60 (2.43)	.650
Eating	4.19 (3.32)	3.79 (3.12)	.365
Punding/Hobbyism	6.63 (5.16)	7.49 (5.34)	.335
Total Score	10.71 (7.94)	10.60 (7.86)	.905

^Pairwise comparisons conducted using paired-samples t-tests.
**P <.05*

Table 7.2 PD participant and informant agreement for ICDs assessed by the QUIP-RS (Cohen's Kappa values reported)

ICD	Present Study	Papay et al. (2011)
Gambling	.41	.55
Sex	.68	.38
Buying	.25	.13
Eating	.14	.40
Punding/Hobbyism	.08	*

Note: Cohen's Kappa conventions are as follows: < 0.2 is no agreement, 0.21 - 0.4 fair agreement, 0.41- 0.6, moderate agreement, 0.61 – 0.8 substantial agreement, and > 0.81 near perfect agreement.
**Value was not reported*

The results of the models (see Figure 7.1 and Figure 7.2) are summarised in Table 7.3. The models indicated that both the informant scores and the self-report scores on the QUIP-RS related to engagement in impulsive behaviours for the SERB. The interaction terms were not significant in either model, indicating that the discrepancy scores did not moderate the relationship between the engagement in impulsive behaviours and self/informant reported impulsivity. However, the interaction term in model two (Figure 7.2) did approach significance. To investigate this further, a Johnson and Neyman test was conducted using PROCESS in SPSS version 24. The Johnson and Neyman test indicates whether the predictor variable (Self-reported QUIP-RS) demonstrates a significant relationship with the criterion variable (engagement in impulsive behaviours - SERB) across different values of the moderator variable (discrepancy score; Miller, Stromeyer, & Schwieterman, 2013). The analysis indicated that the self-reported QUIP-RS scores significantly correlated with SERB scores across 89% of the values of the discrepancy score. When the discrepancy score exceeded 18.9 (self - informant), the relationship between self-reported QUIP-RS scores and the SERB was non-significant. This suggests that when the PD participants reported much higher impulsivity on the QUIP-RS than their informants, their self-reported impulsivity was no longer significantly associated with their engagement in impulsive behaviours.

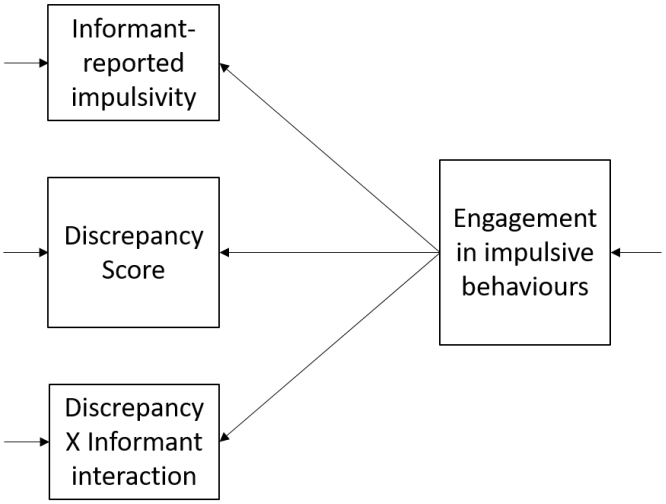

Figure 7.1 Diagram of model one which examined whether the relationship between the PD participant engagement in impulsive behaviours and informant-reported impulsivity was moderated by the discrepancy score.

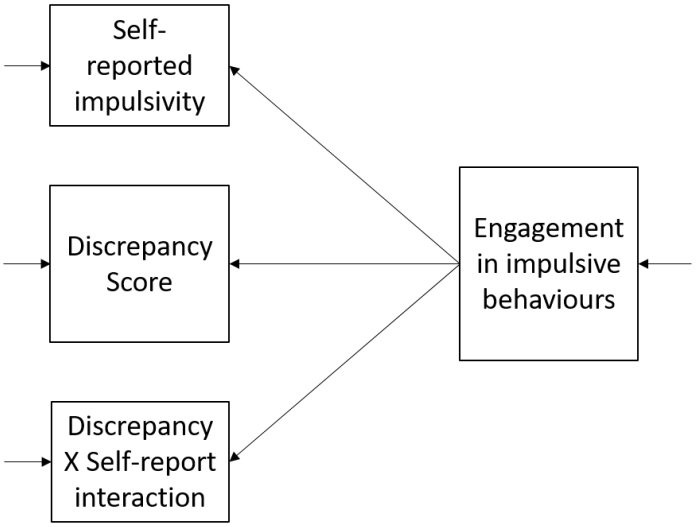

Figure 7.2 Diagram of model two which examined whether the relationship between the PD participant engagement in impulsive behaviours and self-reported impulsivity was moderated by the discrepancy score.

Table 7.3 Moderation model results. Standardised regression coefficients (β) are reported with standard errors and p values.

SERB score regressed on	β	SE	*p* value
Model 1			
Informant QUIP-RS	.18	.04	<.001
Discrepancy score	.01	.06	.086
Interaction term	<.00	<.00	.619
Model 2			
Self-report QUIP-RS	.19	.04	<.001
Discrepancy score	.04	.06	.552
Interaction term	-.01	<.00	.068

Note: A significant interaction term indicates a significant moderating effect of the interaction term.

7.5 Discussion

Hypothesis one was partially supported by the present results. The PD participants' and their informants' responses to the QUIP-RS indicated that they had a moderate degree of agreement on the presence of gambling and sexual ICDs. However, levels of agreement were poor when determining whether eating, shopping, and punding/hobbyism behaviours were present. This suggests that informants and PD participants substantially differ in their appraisal of some impulsive behaviours. Hypotheses two and three were tested to determine whether informants or PD participants are the 'better' source of information when the two disagree. Overall, the results of hypotheses two and three indicate that both the PD participants and their informants reported similarly. These findings highlight the complexity of trying to deduce whether informant or self-reported impulsivity best reflects the issues faced by a person with PD. Nonetheless, the findings of this study have some practical applications for both research and clinical practice.

7.5.1 PD participant and informant responses to the QUIP-RS

There was a moderate degree of agreement between self and informant reported presence of gambling ICDs, and a substantial degree of agreement on the presence of sexual ICDs. Papay et al. (2011) found comparable results for agreement on gambling and sexual ICDs, suggesting that informants and PD participants

generally recognise when these behaviours have reached problematic levels. In contrast, the present results indicated poor levels of agreement for the presence of buying, eating, and punding/hobbyism ICDs. Papay et al. (2011) did not examine punding/hobbyism behaviours, but they did observe poor agreement for buying ICDs. Taken together with the present findings, this suggests that people with PD and their informants tend to disagree on the presence of impulsive buying behaviours. Contrary to the present results, Papay et al. (2011) reported that agreement for eating behaviours was moderate in their sample. Papay et al. (2011) had twice as many participants as the present study and so were more powered. It is possible the present results underestimate the levels of agreement on eating ICDs and should be interpreted with some scepticism.

The present results and those of Papay et al. (2011) demonstrate that when screening for the presence of impulsive gambling or sexual behaviours, both the informant's and PD participant's responses on the QUIP/QUIP-RS can be used with some degree of confidence. The convergence between the two regarding these behaviours suggests that both sources are likely to be somewhat accurate in their appraisal (Papay et al., 2011; Ready & Clark, 2005). In contrast, the low levels of agreement on buying, eating, and punding/hobbyism mean that responses to these questions on the QUIP-RS should be treated with more caution.

7.5.2 Implications for the administering the QUIP-RS

To deal with the poor agreement on buying, eating, and punding/hobbyism ICDs, it may be necessary to combine both the informant and self-report responses to the QUIP-RS, rather than relying on either one alone. The main issue with the QUIP-RS is the over reporting of impulsive behaviours (i.e., false positives), which both people with PD and their informants appear to be equally likely to do (Papay et al., 2011; Weintraub et al., 2012). To improve the accuracy of the QUIP, Papay et al. (2011) recommended that the presence of an ICD should be ruled out if either the informant or the person with PD indicates that a particular ICD is not present. Therefore, to have more confidence in the assessment of buying, eating, and punding/hobbyism ICDs using the QUIP-RS, it may be sensible to employ this tactic and use both informants and PD participants to examine these behaviours to reduce the risk of false positives.

7.5.3 Lack of agreement between informants and people with PD

The lack of agreement between informants and PD participants in terms of impulsive behaviours has been reported in previous research (Baumann-Vogel et al., 2015). The inconsistencies noted between informants and PD participants could be due to one or both sources of information being imprecise in their appraisals. Researchers have proposed that due to issues with insight or wanting to hide undesirable impulsive behaviours that they engage in, PD participants may not accurate in their self-reporting of impulsive behaviours resulting in the observed discrepancies (Ready & Clark, 2005; Weintraub et al., 2015). Informants may also be inaccurate in their appraisals of people with PD for several reasons. Informants are limited to describing behaviours that they can directly observe (McKinlay et al., 2008). Therefore, informants cannot report the on the presence of behaviours or issues that the person with PD is hiding from them (McKinlay et al., 2008). Similarly, informants are not able to perceive the thoughts of the person with PD, which could be a valuable source of information to understand whether someone is having issues such as depressive thoughts, apathy, and impulsive urges (Valentino et al., 2018). It has also been proposed that informants may not always be willing to disclose if the person with PD is engaging in some behaviours, out of a sense of loyalty to that person (McKinlay et al., 2008).

In the present study, PD participants and their informants disagreed on the presence of some behaviours assessed by the QUIP-RS more so than others. There are a couple of explanations for this finding. First, some behaviours are likely to be more obvious to an observer than other behaviours, and as such, are more likely to be noticed by informants (Papay et al., 2011). Often the informant is the spouse of the person with PD (Ricciardi et al., 2016). Therefore, impulsive behaviours that are sexual in nature are likely to be harder to hide than other ICDs, which could explain why the reporting of sexual ICDs demonstrates consistent agreement across the present study and previous research (Papay et al., 2011; Ricciardi et al., 2016). Second, people with PD and their informants are often lay people, and may find it difficult to determine when some behaviours have reached clinically problematic levels (Papay et al., 2011). The present results suggest that it might be easier for both informants and people with PD to recognise when gambling or sexual behaviours have reached a problematic point, compared to hobbyism/punding behaviours. In line with this explanation, to a lay person excessive engagement in hobbyism/punding

behaviours is likely to seem more benign than problematic sexual or gambling behaviours. It is even possible that a peer of someone with PD would be relieved that the person with PD is engaging in an activity that they find rewarding and is seemingly innocuous.

7.5.4 Determining the best source of information for impulsivity

Hypotheses two and three were tested to examine whether informants provide a better appraisal of impulsivity than the PD participants. Hypothesis two was not supported by the results, the relationship between the informants' appraisal of impulsivity and the PD participants' engagement in impulsive behaviours was not moderated by the discrepancy score. The informants' responses to the QUIP-RS demonstrated a significant relationship with the PD participants' engagement in impulsive behaviours, which suggests that informants can accurately report impulsive tendencies in PD. However, the strength of this relationship did not increase when there was a greater disagreement between the two sources of information. The present results suggest that when the informants and PD participants disagree, the informant is not a better source of information.

Hypothesis three was partially supported by the present findings. As expected based on the results of chapter five (study one), the PD participants self-reported QUIP-RS scores related to their engagement in impulsive behaviours. Additionally, there was a trend toward the discrepancy score moderating this relationship. Exploring the moderating effect of the discrepancy score further using a Johnson and Neyman test revealed that the relationship between self-reported impulsivity and engagement in impulsive behaviours became non-significant when the discrepancy score exceeded 18.9. As the discrepancy score was calculated by subtracting the informant's score from the PD participant's score, a higher discrepancy score indicates that the PD participant rated themselves as being more impulsive than their informant did. The present results suggest that when PD participants considered themselves to be substantially more impulsive than their informants did, their self-reported impulsivity no longer correlated with their own engagement in impulsive behaviours. This suggests that these participants overestimated their own impulsivity, as while they considered themselves to be more impulsive than their informants, this did not fit with their engagement in impulsive behaviours on the SERB. The Johnson

and Neyman test revealed that this applied to 11% of the participants (discrepancy score above 18.9).

7.5.5 Overestimation of difficulties

The present findings are in line with a number of studies that have found some people with PD are prone to overestimating their difficulties (Bloomfield et al., 2016; den Brok Melina et al., 2015; Kudlicka et al., 2013). Researchers and clinicians may need to consider this when assessing impulsivity in PD. People with PD and relatively intact cognitive/motor abilities appear to be the most likely to overestimate their difficulties (Bloomfield et al., 2016; den Brok Melina et al., 2015; Kudlicka et al., 2013). In the present study, PD participants who thought that they were much more impulsive than their informants did appeared to be inaccurate, as their self-reported impulsivity did not correlate with their engagement in impulsive behaviours. Likewise, PD participants with intact executive functioning in the study by Kudlicka et al. (2013) reported having significantly worse executive functioning than their informants' assessment would suggest. Woods and Kneebone (2016) also observed that participants who performed within the normal range on memory tasks self-reported having more memory difficulties than their informants thought they had. While this inclination for people with PD to overstate their issues is not replicated across all studies comparing self and informant reported abilities in PD, it would appear that subsets of people with PD are more likely to make this error.

One potential explanation for the overestimation of problem behaviours is that people with PD develop an attentional bias to monitor PD related changes in their cognitive abilities/behaviours. As PD is known to affect both physical and cognitive abilities (Kalia & Lang, 2015), people with PD are likely to expect declines in these domains, and as a result, might pay more attention to these areas to detect any PD related difficulties. Attentional biases to health-related stimuli have been reported in people with health anxiety. People with health anxiety suffer from an unfounded fear that they have a serious health issue (Witthöft et al., 2015). They interpret normal bodily sensations as indications of serious health issues, which in turn causes them to experience significant distress (Jasper & Witthöft, 2011). Due to their belief that they have a serious illness, people with health anxiety become hypervigilant to detecting changes in their bodily sensations and continually direct their attention to monitoring health related stimuli (Jasper & Witthöft, 2011). If a

change in these sensations is detected it is often misattributed to a non-existent illness, whereas in reality it is likely to be benign (Mier et al., 2017).

Like people with health anxiety, people with PD may also develop an attentional bias to monitoring health related stimuli. It is well established that people with PD experience increased anxiety (Broen et al., 2016), and most anxiety disorders are associated with attentional bias to anxiety inducing stimuli (Kaur, Butow, & Thewes, 2011). It could be reasonable to suggest that because anxiety is so prevalent in PD, some people with PD worry about their disease related changes and become hypervigilant to detecting these changes. As such, they develop attentional biases to monitor whether they are experiencing changes in their behaviours, cognitive abilities, and motor skills. If, for example, people with PD become hypervigilant to changes in their impulsive behaviours, memory, depression, and motor functioning, they may sometimes misattribute 'normal' fluctuations within these domains as being due to their PD. A person with PD might expect their memory to decline, therefore a trivial memory error could be misinterpreted as an indication that their memory is deteriorating due to PD. Similarly, as the link between impulsivity and PD is increasingly recognised by health professionals (Grall-Bronnec et al., 2018), people with PD are likely to be warned that PD/dopaminergic medications can lead to increased impulsivity. Some people with PD might become extra vigilant to detecting changes in their impulsive tendencies and overstate their impulsive tendencies. Future research should examine whether people with PD are particularly attentive to health-related stimuli, especially for stimuli associated with PD symptoms.

7.5.6 Efficacy of using informants for assessing impulsivity

In the moderation models, both self and informant reported impulsivity on the QUIP-RS demonstrated comparable significant relationships with the PD participants' engagement in impulsive behaviours (see Table 7.3). Therefore, the QUIP-RS demonstrated a relationship with engagement in impulsive behaviours irrespective of whether it was the PD participant or the informant completing the questionnaire. Therefore, neither the informants nor the PD participants appear to be a superior source of information, but promisingly, they both seemed to be able to report impulsivity using the QUIP-RS with a reasonable degree of accuracy. While these results do not assist in determining whether informants or people with PD are a

better source of information for assessing impulsivity, perhaps they are a realistic reflection of the heterogeneity that exists in these populations. The accuracy of both people with PD and their informants varies due to a number of factors (McKinlay et al., 2008). Therefore, aggregating these groups together may mask the individual characteristics that make informants or PD participants better sources of information.

A couple of factors have been identified as influencing informant appraisals (Schiehser et al., 2013). Informants who experience greater caregiver burden report more severe neuropsychiatric problems in the person with PD who they care for (McKinlay et al., 2008). If an informant experiences higher levels of depression and caregiver burden, they are more likely to disagree with the PD person's self-reported abilities/behaviours (Schiehser et al., 2013).

More research has explored how informant characteristics can affect their appraisal of people with dementia (Huang, Chang, Tang, Chiu, & Weng, 2009). Like PD, dementia is associated with cognitive impairments that could affect the validity of self-reported assessments. As such, assessments of people with dementia commonly use nominated informants to overcome this issue (Moon, Townsend, Dilworth-Anderson, & Whitlatch, 2016). Informants are often required to assess whether the person they know with dementia has a good quality of life, but research has identified numerous factors which affect this appraisal (Huang et al., 2009; O'Shea et al., 2018). Informants consistently provide significantly lower quality of life ratings for the person with dementia when they have a poorer relationship with that person, when their own quality of life is lower, when they have anxiety and/or depression, and when they experience greater caregiver burden (Huang et al., 2009; Moon et al., 2016; O'Shea et al., 2018). Although these factors consistently affect an informant's ability to objectively interpret quality of life in dementia, overall informant quality of life appraisals are associated with dementia symptom severity, suggesting that they do offer a valid assessment of wellbeing in dementia (O'Shea et al., 2018).

These findings from PD and dementia research suggest that while informants are a useful source of information, they are vulnerable to biases. This is particularly the case when they are experiencing caregiver burden, depression, anxiety, and a lower quality of life. When accessing informants as a proxy assessment in PD, the individual characteristics of the informants should be considered to discern whether their own situation may impact upon their assessment of the person with PD. More

research is needed to understand the factors that may influence informants' appraisals of people with PD. Rather than comparing informants to people with PD as groups, it may be more useful to focus on the characteristics of both people with PD and their informants that can negatively impact on their ability to provide a sound assessment. This will enable clinicians to identify whether a particular person is likely to be a valid source of information. Furthermore, identifying the factors that bias PD participant and informant will allow researchers to control for any influence they could have on the findings of studies, including research examining impulsive behaviours.

7.5.7 Limitations

The current study assumes that the engagement in impulsive behaviours as assessed by the SERB is a valid indication of the PD participants' actual engagement in impulsive behaviours. The SERB has been designed to be an objective assessment of a person's engagement in a wide-range of impulsive behaviours, but it is still dependent on the person with PD to identify and acknowledge that they engage in the examined behaviours. If the person with PD is inaccurate in their reporting, then the SERB will not be an accurate reflection of the PD participant's true engagement in impulsive behaviours. While an objective behavioural measure of impulsivity could be preferable to using the SERB to avoid these issues, the findings of chapter six (study three) suggested that behavioural tasks of impulsivity may not be entirely valid. Therefore, the SERB was selected to assess actual engagement in impulsive behaviours. While both of these measures may have their limitations, the present results demonstrated a significant relationship between the two, which does suggest that they were able to accurately able to capture some aspects of impulsivity. Furthermore, this relationship was evident regardless of whether the informant or PD participant completed the QUIP-RS.

The literature suggests that characteristics of nominated informants can be an important determinant in terms of the validity of their appraisals. The present study did not examine the characteristics of the nominated informants, and as such, it cannot examine whether the characteristics of the informants affected the validity of their appraisals. Future research should investigate whether nominated informant characteristics affect their appraisals of impulsivity in PD.

7.5.8 Significance

No previous research has examined how self-report and informant scores on the QUIP-RS relate to engagement in impulsive behaviours in PD, and whether discrepancy scores moderate this relationship. The present results demonstrate that both people with PD and their informants can provide a valid appraisal of impulsivity, with neither source outperforming the other. To achieve the most accurate assessment of impulsivity, it would be advisable to use both sources of information whenever possible. Doing so is likely to provide a more holistic assessment of impulsivity that is less vulnerable to bias compared to using one source of information. The present results also hint that over-reporting of impulsive behaviours could be an issue for some people with PD that do not have an issue with impulsive behaviours. PD research in other domains has also suggested that this can be an issue for some people with PD, future research should explore this phenomenon further. Rather than comparing one group to another, future research should further explore the contextual situations that make assessments provided by informants and PD participants more/less valid.

Chapter 8 General discussion

This thesis examined the methods that are used to assess impulsivity in PD. In doing so, the project sought to increase to our understanding of impulsive behaviours in PD and inform future approaches for identifying problematic impulsive behaviours in PD. Four studies were conducted, each examined a different aspect of measuring impulsivity in PD. This chapter will summarise the main findings of each study, discuss how these findings fit within the present knowledge base, and describe how they may contribute to the literature. This chapter will also discuss the practical implications of the findings for both research and clinical practice, and will recommend directions for future research.

8.1 Summary of research findings.

8.1.1 Study 1

Investigating the relationship between self-reported impulsivity and risky behaviours in PD.

Study one is the first study to examine whether the QUIP-RS is limited by its focus on specific impulsive behaviours. Study one also explored whether measuring impulsivity in terms of attraction to reward and fear of punishment (using the BIS/BAS scale) would be a more sensitive means of identifying impulsivity issues in PD than the QUIP-RS. A hierarchical multiple regression was conducted with engagement in impulsive behaviours (SERB total score) as the outcome variable. The BIS/BAS subscales were entered at step one of the regression, and together predicted a significant amount of variance in the SERB total score (adjusted $R^2 = .15$, F (4, 61) = 3.902, $p = .007$). When the QUIP-RS was entered at step two, it accounted for an additional 18% of variance in the SERB total score ($\Delta R^2 = .18$, ΔF (1, 60) = 16.91, $p = <.001$). In combination, all of the predictor variables explained 33% of variance in the SERB overall score (adjusted $R^2 = .33$, F (5, 60) = 7.32, $p <$ .001). However, only the QUIP-RS independently accounted for a significant amount of variance in the engagement in impulsive behaviours.

Scores on the QUIP-RS were related to alcohol consumption ($r = .26$), drug use ($r = .47$), gambling ($r = .41$), aggression ($r = .3$), general risky behaviours ($r =$ .45), and inappropriate comments ($r = .36$). Study one also revealed that greater

behavioural activation (attraction to reward) was associated with the higher scores on the QUIP-RS (BAS Drive (r = .35), BAS Fun Seeking (r = .44), and BAS Reward Responsiveness (r = .32)). Behavioural inhibition was not significantly correlated with the QUIP-RS.

8.1.2 Study 2

An examination of the impact of insight on the relationship between self-report measures of impulsivity (QUIP-RS, BIS/BAS) and self-reported risky behaviours in PD.

Study two is among the first to compare people with PD and an ICD to people with PD and no ICD in terms of their level of insight. Mack et al. (2013) previously found that people with PD and an ICD had greater insight than those with no ICD (as indicated by higher composite scores on the Beck Cognitive Insight Scale). These findings were unexpected, Mack et al. (2013) predicted that the opposite would be true and that insight would be impaired in the ICD group. However, study two also revealed a similar unexpected pattern of findings. When using the factor structure proposed in the original validation of the Beck Cognitive Insight Scale by Beck et al. (2004), the results demonstrated no significant difference in terms of insight between the ICD positive group (M = 4.84, SD = 3.33) and the ICD negative group (M = 3.79, SD = 5.09), t(57.3) = .99, p = .32. When an alternative factor structure suggested by Kao and Liu (2010) was employed, the average composite score for the ICD group (M = .47, SD = 4.83) was significantly higher than the no ICD group (M = -2.09, SD = 3.84), t(64) = 2.39 , p = .02, d = .59.

Study two is the first study to examine whether insight would moderate the relationship between self-reported impulsivity in PD and engagement in impulsive behaviours. Several models were run in Mplus to examine whether insight moderated the relationship between the QUIP-RS, BAS Drive, BAS Funseeking, BAS reward responsiveness, and engagement in impulsive behaviours. Insight did not moderate the relationship between any of the self-reported measures of impulsivity and engagement in impulsive behaviours.

8.1.3 Study 3

Exploring the validity of behavioural impulsivity tasks in PD

Study three was the first to test whether multiple behavioural impulsivity tasks aggregated together would predict engagement in impulsive behaviours in PD. Several models were run in Mplus which determined that the aggregated behavioural tasks did not relate to the PD participants' engagement in impulsive behaviours. Furthermore, none of the behavioural tasks independently demonstrated an association with the participants' engagement in impulsive behaviours.

Study three also examined whether the typically poor relationship between self-report and behavioural measures of impulsivity could be improved using an aggregated score for the behavioural tasks. The aggregated score for the behavioural tasks did not relate to the QUIP-RS, BAS fun, BAS drive, or BAS reward responsiveness. Additionally, when examined individually, none of the behavioural tasks correlated with these self-reported measures of impulsivity.

Following this, study three was the first to examine whether insight might moderate the relationship between a participant's performance on the behavioural tasks and their self-reported impulsivity, such that a higher level of insight would strengthen the relationship. When correcting for multiple comparisons, insight did not moderate the relationship between any of the self-reported impulsivity measures (QUIP-RS, BAS fun, BAS drive, or BAS reward responsiveness) and an overall Z-score for the behavioural measures of impulsivity.

8.1.4 Study 4

The utility of nominated informant appraisals for assessing impulsivity in PD

Study 4 examined the agreement between PD participants and their informants when they complete the QUIP-RS. The PD participants and informants demonstrated a moderate degree of agreement for the presence of gambling ($\kappa = .41$) and sexual ICDs ($\kappa = .68$). However, agreement on the presence of eating ($\kappa = .14$), shopping ($\kappa = .25$), and punding/hobbyism ($\kappa = .08$) behaviours was poor.

Study four was the first to examine whether a discrepancy score (PD participant QUIP-RS score– informant QUIP-RS score) would moderate the relationship between responses to the QUIP-RS and the PD participants' engagement in impulsive behaviours. Two models were run to test this, the first indicated that the informant's responses to the QUIP-RS related to the PD participant's engagement in

impulsive behaviours. However, this relationship was not moderated by the discrepancy score. The second model revealed that there was a trend was a trend toward the discrepancy score moderating the relationship between the PD participants' self-reported impulsivity and their engagement in impulsive behaviours. Exploring the moderating effect of the discrepancy score further using a Johnson and Neyman test revealed that the relationship between self-reported impulsivity and engagement in impulsive behaviours became non-significant when the discrepancy score exceeded 18.9.

8.2 Contribution of findings to the literature

Initially seen as a motor disorder resulting from the death of dopaminergic cells in the substantia nigra, PD is now understood to be complex disorder that is associated with atrophy in multiple areas of the brain and functional changes to several neurotransmitter systems (Barone, 2010; Kehagia et al., 2013). Non-motor issues are now acknowledged as being a significant aspect of PD symptomology, and have attracted increased attention from research and clinicians (P. Martinez-Martin et al., 2015; Prakash et al., 2016). Approximately 20 years ago, impulsive behaviours were first noted as a non-motor symptom associated with PD (Weintraub, 2019). It is now recognised that a significant number of people with PD experience ICDs (Corvol et al., 2018), and that these behaviours can significantly affect the quality of life of people with PD and their friends/family (Leroi et al., 2012). Identifying and treating impulsive behaviours in PD remains a major challenge for clinicians (Leeman et al., 2012; Perez-Lloret et al., 2012). The development of effective methods to identify these behaviours is a priority for PD research.

8.2.1 The measurement of impulsive behaviours in PD

Early research into impulsivity in PD used pre-existing measures designed to identify impulsive behaviours in other populations (Mestre et al., 2013). These measures were not designed for use in PD and only assessed a specific impulsive behaviour, such as using the South Oaks Gambling Screen (Lesieur & Blume, 1987) to examine impulsive gambling behaviours (Mestre et al., 2013). Pre-existing measures did not assess impulsive behaviours that are more specific to PD, like hobbyism/punding behaviours and dopamine dysregulation syndrome (Weintraub et

al., 2009). One of the first measures created specifically for PD was the QUIP, which screens for the presence of several ICDs (Weintraub et al., 2009) and has since become one of the most validated measures for assessing these behaviours in PD (Pablo Martinez-Martin et al., 2016). Weintraub et al. (2012) updated the QUIP to incorporate a rating scale format (the QUIP-RS), so that clinicians and researchers could assess the severity of ICDs and identify when a person had sub-clinical impulsive behaviours.

A recent review of measures that assess impulsive behaviours in PD recommended using the QUIP-RS for diagnostic screening and for assessing the severity of ICDs (Evans et al., 2019). That said, the measure does have some shortcomings. Pablo Martinez-Martin, Rodriguez-Blazquez, and Catalan (2018) noted that over a month follow-up period, their participant's scores on the QUIP-RS decreased. This raises questions about the stability of QUIP-RS scores over time. Concerns have also been raised regarding the sensitivity and specificity of the measure (Probst et al., 2014). Nonetheless, the measure is quick to administer, relatively simple, and has demonstrated good internal consistency and the ability to identify the presence of ICDs in PD (Pablo Martinez-Martin et al., 2018; Weintraub et al., 2012). While it has its limitations, the QUIP-RS is still it is one of the most effective measures for identifying impulsive behaviours in PD (Evans et al., 2019).

Study one examined whether the QUIP-RS might be limited by its focus on ICDs. Unexpectedly, the QUIP-RS predicted engagement in a range of risky behaviours beyond the ICDs that it directly screens for (alcohol consumption, drug use, gambling, aggression, general risky behaviours, and inappropriate comments). Therefore, the QUIP-RS seems to capture some general aspect of impulsivity that underlies engagement in multiple impulsive behaviours, and could potentially be used as an overall indication of a person's impulsive tendencies. The results of study one demonstrate that researchers using the QUIP-RS can be reasonably confident that they will not overlook impulsive people with PD who engage in behaviours beyond the ICDs that the QUIP-RS screens for. It seems likely that the more general impulsive behaviours examined by the SERB are often co-morbid with ICDs, which explains why higher scores on the QUIP-RS were associated with increased engagement in these behaviours according to the SERB.

Study two revealed that insight did not moderate the relationship between self-reported impulsivity and the engagement in impulsive behaviours. This indicates

that higher levels of insight are not necessary for a person to be able to self-report their impulsivity. Therefore, the assessment of problematic impulsive behaviours in PD does not appear to be contingent on a person having higher levels of insight. This finding is inconsistent with studies that have shown people with PD have difficulties reporting their own abilities/behaviours. Research has shown that people with PD may not always be completely aware of their motor symptoms (Amanzio et al., 2010; Maier & Prigatano, 2017), olfactory issues (Kawasaki et al., 2016), and cognitive impairments (Kudlicka et al., 2013). This lack of awareness has been attributed to impaired insight, which affects the ability of people with PD to self-report their issues (Kudlicka et al., 2013). However no studies had yet empirically tested whether impaired insight affects the strength of the relationship between self-reported abilities and actual abilities. Study two did test this, and the results suggest that the validity of self-report impulsivity measures in PD is unlikely to be affected by a person's level of insight.

Behavioural impulsivity tasks have been endorsed as a means to determine a person's propensity to engage in problematic impulsive behaviours, and it has been suggested that such tasks overcome several of the limitations of self-report measures (Sharma et al., 2014). However, study three casts doubt on the ecological validity of using behavioural impulsivity tasks in PD. Research examining the link between behavioural impulsivity tasks and impulsive behaviours has often yielded mixed results, including studies employing the IGT (Buelow & Suhr, 2009) and the BART (Davis-Gahagen, 2014), both of which were used in study three. A meta-analysis revealed that behavioural impulsivity tasks have demonstrated associations with real-world impulsive behaviours, the strength of this association was fairly small (r = .21; Sharma et al., 2014). While limited research has explored this relationship in PD, the results of study three offer preliminary evidence to suggest that any inferences made using behavioural impulsivity tasks in PD should be treated with caution.

The findings of study four indicate that nominated informants are a valid source of information when assessing impulsive behaviours in PD, and should be included when assessing these types of behaviours. Previous studies have also supported the use of informants in PD research for assessing several abilities/behaviours including cognitive functioning (Kudlicka et al., 2013; Naismith et al., 2010), memory (Woods & Kneebone, 2016), and apathy (Fitts et al., 2015). However, research examining the utility of informants had not consistently found

their appraisals to be valid (Lanni et al., 2014; Valentino et al., 2018). It is likely that individual characteristics and contextual factors could affect the accuracy of informants, and these should be taken into account when they are reporting impulsive behaviours in PD (McKinlay et al., 2008; Schiehser et al., 2013). The results also suggested a slight tendency for less impulsive people with PD to overstate their impulsive tendencies. When PD participants rated themselves as being significantly more impulsive than their informants did, their self-reported impulsivity did not relate to their actual engagement in impulsive behaviours (as measured by the SERB). Several other studies have suggested that people with PD can overestimate their issues in several areas such as apathy, executive functioning, and memory (Bloomfield et al., 2016; den Brok Melina et al., 2015; Kudlicka et al., 2013)

Study four had specific implications for informant and self-reported responses to the QUIP-RS. In line with Papay et al. (2011), study four demonstrated that informants and PD participants had a high degree of agreement on the presence of sexual and gambling ICDs. This high degree of agreement on these behaviours suggests that either source of information is likely to give a reasonably accurate indication as to whether someone with PD experiences problematic sexual or gambling behaviours (Ready & Clark, 2005). However, when screening for eating, shopping, and punding/hobbyism behaviours, levels of agreement were poorer. When examining these behaviours using the QUIP-RS the results should be treated with more caution. For these ICDS, it is advisable to employ the recommendation of Papay et al. (2011) and discount the presence of an ICD if either the informant or PD participant indicates that a particular ICD is not present. Doing so will reduce the risk of false positives that can be an issue for the QUIP-RS (Weintraub et al., 2012)

8.2.2 The nature of impulsivity in PD

Impulsivity is a difficult construct to define and attempts to conceptualise impulsivity have included personality based models (Carver, 2005), biological models (J. A. Gray, 1987), neurological models (Bechara, 2005), and a combination of these models (Patton et al., 1995). In chapter two it was proposed that, underpinning these different approaches to impulsivity, is the notion that impulsivity results from an over attraction to reward and an under sensitivity to punishment. This account of impulsivity could explain how the pathogenesis of PD and dopaminergic medications used to treat PD might result in heightened impulsivity. Frontal areas are

typically impaired in PD, and these areas are associated with the inhibition of reward seeking behaviour potential reducing the inhibition of impulsive behaviours (O'Callaghan et al., 2013). PD is also associated with changes to the brain's dopaminergic reward pathways that drive the perusal of reward, which could result in increased reward seeking behaviours (Cossu et al., 2018). These reward pathways are at risk of being overdosed with excess dopamine when people with PD use dopaminergic medications, creating a hypersensitivity to rewarding stimuli (Averbeck et al., 2014). Exploring the nature of impulsivity in PD may help us to understand why some people with PD are impulsive, and could hint as to how PD-related changes to the brain result in heightened impulsivity.

Study one demonstrated that higher scores on the QUIP-RS are related to behavioural activation as measured by the BIS/BAS scale. Congruent with these findings, behavioural activation as measured by the BIS/BAS scale has been related to impulsive behaviours in PD previously (Balconi, Angioletti, Siri, Meucci, & Pezzoli, 2018). These results suggest that engagement in ICDs in PD is related to an over attraction to reward, rather than a weak fear of punishment. Therefore, it may be PD-related changes to limbic reward pathways that produces impulsive behaviours in PD, as it is these areas that are thought to produce the drive to seek out rewarding stimuli. In line with this explanation and the results of study one, a number of imaging studies have observed that impulsive people with PD have abnormal activation in dopaminergic limbs reward pathways in response to rewarding stimuli (Claassen et al., 2017; Evans, Pavese, et al., 2006; Vitale et al., 2011; Voon et al., 2010).

Limited research has examined this relationship between the QUIP-RS and the BIS/BAS scale, but in a contradictory to the results of study one, Goerlich-Dobre et al. (2014) reported a significant negative relationships between the BAS subscales and QUIP-RS total score. These results are puzzling when attraction to reward is usually associated with greater impulsivity (Cross et al., 2011; Wang et al., 2016). The study by Goerlich-Dobre et al. (2014) examined alexithymia in PD and did not explore or explain the observed negative relationship between the attraction to reward and the QUIP-RS. It is difficult to explain why their results are so different, but they do indicate that the findings of study one should be treated with a degree of caution until further research is conducted.

Study one also demonstrated that impulsive behaviours in PD go beyond the six commonly identified ICDs included in the QUIP-RS. The findings suggest that heightened impulsivity in PD can manifest in numerous different behaviours. Furthermore, as these other behaviours were associated with the QUIP-RS total score, it is likely that they are comorbid with ICDs. Consistent with study one, a number of case studies have also reported instances of people with PD developing issues with a range of different risky behaviours (Avanzi et al., 2008; Bienfait et al., 2010; O'Sullivan et al., 2010). Therefore, the results of study one indicate that an increased attraction to reward resulting from PD (or PD medications) can foster the development of many different risky reward seeking behaviours as well as ICDs.

Multiple authors have suggested that people with ICDs in PD should experience greater impairments to frontal areas and abilities dependent on frontal areas than those without ICDs in PD (Bentivoglio et al., 2013; Martini et al., 2018; Santangelo et al., 2017). It would be expected that people with ICDs in PD would experience reduced insight compared to those with no ICDs, as insight is dependent on fontal functioning (David et al., 2012). Contrary to this, the findings of study two show that people with PD and ICDs had higher levels of insight than those with PD and no ICDs. Although these results were unexpected, they are in line with a similar study by Mack et al. (2013), suggesting that the results of study two have some credibility. The findings provide some indication that, despite the nature of the disease, people with PD can retain intact insight into their own behaviour.

A potential explanation for these findings is that people with ICDs in PD do not demonstrate impairment to frontal abilities any more so than people with PD and no ICDs. Studies have revealed that only a few specific frontal abilities are more impaired for PD people with ICDs vs PD people without ICDs (Martini et al., 2018; Santangelo et al., 2017). Therefore, disruptions to frontal areas associated with impulsivity in PD appear to affect some behaviours/abilities more so than others. Based on the present findings and those of Mack et al. (2013), insight seems to be fairly robust against structural changes associated with impulsivity in PD. As such, it may be unwise to assume that because ICDs in PD are associated with frontal impairments, this will result in all frontal abilities being impaired for these people. At the very least, insight and the majority of executive functions appear to be largely unaffected relative to people with PD and no ICDs (Mack et al., 2013; Martini et al., 2018; Santangelo et al., 2017).

Overall these findings reveal several key points regarding the measurement and nature of impulsivity in PD. First, Researchers and clinicians can be confident that the QUIP-RS provides a sound assessment of impulsive behaviours in PD. Second, people with impulsivity issues in PD are likely to have the insight to report their impulsive behaviours accurately. Third, behavioural impulsivity tasks should be used with caution. Fourth, nominated informants represent a promising avenue for complimenting self-report measures of impulsivity that warrants further investigation. Fifth, impulsivity in PD is potentially driven by an increased attraction to reward that can result in excessive engagement in pleasurable behaviours. Overall, these findings further our understanding of impulsivity in PD and can be applied to improve research and clinical practice. This should result in translational benefits to people with PD and their friends/family, which is the most important goal of this research.

8.3 Implications for clinical practice

Treatment options for managing impulsive behaviours in PD remain limited (Ramirez-Zamora et al., 2016). One method used is to reduce or discontinue dopamine agonist medications (Weintraub, 2019). Evidence for the use of other pharmacological treatments is scare and has provided conflicting results (Weintraub, 2019). Using a randomised control trial, Okai et al. (2013) demonstrated that cognitive behavioural therapy can significantly reduce impulsivity symptoms in PD. The findings of study one may help us to understand how therapy could be used to treat ICDs in PD. Study one revealed that behavioural activation was associated with higher scores on the QUIP-RS. A therapy called Behavioural Activation Therapy focuses on the relationship between reinforcement and behaviour, and teaches people to engage in healthy behaviours that they find rewarding (Russo et al., 2018). Okai et al. (2013) used a similar technique by encouraging their PD participants to engage in activities that they find rewarding that were not associated with their impulsive behaviours. This may have helped the people with PD reduce their problematic impulsive behaviours by re-directing their over attraction to reward to other behaviours, thereby helping people to satisfy their need for increased reward seeking in a healthier manner. The results of study one and Okai et al. (2013) suggest that

therapies that moderate the attraction to reward associated with impulsivity in PD may be an effective treatment option.

Study one demonstrated that impulsivity in PD is not limited to the six commonly identified ICDs, but likely expresses itself through a number of different behaviours. Therefore clinicians need to consider that ICDs may be comorbid with other impulsive behaviours such as consuming more alcohol, heightened aggression, and inappropriate comments. If a clinician suspects heightened impulsivity or confirms the presence of an ICD, they should take the time to investigate and understand the extent of the impulsive behaviours the PD client engages in, to ensure that their treatment plan will cover the range of impulsive behaviours that the client experiences.

Some studies have suggested that people with PD may not be accurate when self-reporting their own impulsive behaviours, potentially due to reduced insight (Baumann-Vogel et al., 2015; Mack et al., 2013). Study two suggests that people with ICDs in PD do not have reduced insight, which means that clinicians can be fairly confident that people with ICDs in PD have the insight to be able successfully self-report their impulsive behaviours. Nonetheless, nominated informants could be an invaluable source of information to complement self-reported impulsivity in PD (Baumann-Vogel et al., 2015; Papay et al., 2011). Study four revealed that the nominated informants' appraisals of the PD participants' impulsivity related to the PD participants' engagement in impulsive behaviours. Therefore, these results suggest that when peers/family members of people with PD are available to provide information, it could be good practice to also ask these people about the PD client's impulsivity, to provide a more holistic account of the situation. This could extend to monitoring the severity of ICDs over time, which could be particularly important when attempting to treat these behaviours.

8.4 Recommendations for future research

1. Further determine the extent of impulsive behaviours in PD

Study one revealed that a range of impulsive behaviours in PD are likely to exist. At present, there is a paucity of research examining behaviours beyond the six common identified ICDs in PD. The non ICD behaviours examined in study one that were associated with impulsivity in PD have been reported to have detrimental

effects on the lives of people with PD and their peers (Bruno et al., 2016; Mursaleen & Stamford, 2016; Squeglia et al., 2014). Therefore, research needs to explore the full scope of potential impulsive behaviours in PD or risk overlooking people with PD that experience problematic impulsive behaviours.

2. **Examine the psychometric properties of the QUIP-RS**

The QUIP-RS is one of the most comprehensive measures of ICDs in PD (Evans et al., 2019). However, research examining the psychometric properties of QUIP-RS is somewhat limited. Concerns have been raised regarding the sensitivity and specificity of the measure (Probst et al., 2014), and the test re-test reliability (Pablo Martinez-Martin et al., 2018) The results of the present study suggest that like the QUIP, agreement between people with PD and their informants is poor for some ICDS (Papay et al., 2011). Future research should further examine the properties of the QUIP-RS, with the ultimate aim of further refining and developing the QUIP-RS to ensure that we have access to the best measures possible for impulsive behaviours in PD.

3. **Investigate the validity of behavioural impulsivity measures in PD**

The results of study three cast doubt on the validity of behavioural tasks for the assessment of impulsivity in PD. The behavioural tasks did not relate to engagement in risky behaviours as assessed by the SERB, ICDs as assessed by the QUIP-RS, or behavioural activation/inhibition as measured by the BIS/BAS scale. Numerous PD studies have used behavioural impulsivity tasks, some of which infer that performance on these tasks reflects a person's tendency to engage in impulsive behaviours (Castrioto et al., 2015; Claassen et al., 2011; Simioni et al., 2012). Study three suggests that just because these tasks have demonstrated some ecological validity in the general population, does not mean that they are effective in PD. Future research needs to examine the suitability of using behavioural impulsivity tasks in PD research. Prior to this research, any results and findings derived from these tasks should be treated with a degree of caution.

It is worth noting that new behavioural tasks are continually being developed that may improve on the shortcomings of the tasks assessed in the present thesis. For example, Paliwal, Petzschner, Schmitz, Tittgemeyer, and Stephan (2014) developed a behavioural task called 'Virtual Casino' that 'realistically' mimics slot-machine

gambling in an attempt to create an ecologically valid measure of impulsivity. PD research has shown that performance on the Virtual Casino differentiates between people with ICD vs. no ICD, is associated with self-reported impulsivity, and is linked to differences in structures of the brain that are relevant to impulsive behaviours (Mosley et al., 2019; Paliwal et al., 2019). Future research should continue to evaluate emerging behavioural tasks that could represent new and valid means for assessing impulsivity in PD.

4. **Identify individual characteristics that influence the validity of reporting impulsive behaviours**

Study four demonstrated that both the PD participants and informants are effective for examining impulsivity in PD. While numerous studies have tried to determine which source of information is the best (Kudlicka et al., 2013; Woods & Kneebone, 2016), limited research has examined characteristics of both PD participants and informants that make them a more or less valid source of information. Factors such as depression, caregiver burden, and PD severity have been shown to influence the accuracy of informant appraisals in PD (McKinlay et al., 2008; Schiehser et al., 2013). Future research needs to identify and explore factors that can affect the accuracy of informants and people with PD to report impulsive behaviours. Doing so may enable both clinicians and researchers to better predict which sources of information are going to provide the most valid assessment of impulsivity.

5. **Treatments for impulsivity in PD**

The treatment of these impulsive behaviours was not the focus of the present thesis. Nonetheless, there is a striking lack of research that has examined treatment options for ICDs in PD (Ramirez-Zamora et al., 2016). These behaviours can have serious consequences for people with PD and their families. Indeed, several participants that contributed to the data collection for this thesis disclosed the negative consequences that impulsive behaviours had brought upon themselves and others that they love. It is paramount not only to understand and identify impulsive behaviours in PD, but also to be able to offer evidence based treatments to people affected by this issue. Managing the over attraction to reward that seems to drive

impulsive behaviours in PD (as identified Chapter 4) could serve as a good starting point for treatments.

8.5 Closing words

Since James Parkinson provided the first description of PD, research has dramatically increased our understanding of the disorder. We now have an understanding of the pathogenesis of PD, appreciate that PD affects numerous neurotransmitter systems and areas of the brain, and have identified the idiosyncratic motor and non-motor symptoms of PD. Each of these symptoms represents another challenge to people with PD, to the clinicians who aim to treat these symptoms, and to the researchers who strive to understand these symptoms.

Impulsivity was identified as a symptom of PD relatively recently but despite this, considerable research effort has been directed toward understanding impulsive behaviours in PD. Unfortunately, impulsivity has always been considered a difficult construct to define and measure. These difficulties are further compounded by the complexities of assessing populations with neurodegenerative disorders. Nonetheless, valid measures are crucial to conducting good research. We need to be confident that our instruments capture what they purport to capture to have any degree of confidence in our research findings. Furthermore, valid measures can equip clinicians with useful tools to use in practice.

Research into impulsive behaviours in PD has identified the neural correlates of heightened impulsivity in PD, identified the role that dopamine agonists play in the development of these behaviours, and provided some preliminary evidence as to how we can treat these behaviours. These research findings are helping us to understand the nature of impulsive decision making, which could have implications for assisting clinically impulsive people in other populations.

The present project aimed to assist and inform future research into impulsivity in PD, and I think that it has made some unique contributions to our understanding of this area. This would not have been possible without the generosity of the participants who took part. They were kind enough to selflessly donate their time and effort to contribute to this research project, often knowing that they may never see any direct benefits themselves. Every one of them was willing to briefly let me into their world and share details of their lives, which given the nature of the

project could often be quite personal. I was fortunate enough to see the human side of PD, and I was struck by the diversity of people who I met. Although they differed in many ways, they all warmly welcomed me and shared the same desire to contribute to research in the hope that their efforts may benefit others. I hope my research can do their efforts justice, and I hope that the cumulative efforts of researchers and participants can continue to improve the lives of others.

"A society grows great when old people plant trees in whose shade they know they shall never sit" – Greek proverb.

References

Aarsland, D., Brønnick, K., Alves, G., Tysnes, O. B., Pedersen, K. F., Ehrt, U., & Larsen, J. P. (2009). The spectrum of neuropsychiatric symptoms in patients with early untreated Parkinson's disease. *Journal of Neurology, Neurosurgery, & Psychiatry, 80*(8), 928. doi:10.1136/jnnp.2008.166959

Aarsland, D., & Kramberger, M. G. (2015). Neuropsychiatric symptoms in Parkinson's Disease. *Journal of Parkinson's Disease, 5*(3), 659-667. doi:10.3233/JPD-150604

Abbott, M. W., & Volberg, R. A. (2006). The measurement of adult problem and pathological gambling. *International Gambling Studies, 6*(2), 175-200. doi:10.1080/14459790600928678

Ackerman, P. L., & Wolman, S. D. (2007). Determinants and validity of self-estimates of abilities and self-concept measures. *Journal of Experimental Psychology: Applied, 13*(2), 57-78. doi:10.1037/1076-898X.13.2.57

Adam, P., Richoux, C., & Lejoyeux, M. (2008). Screening for impulse control disorders among patients admitted to a french psychiatric emergency service. *The Open Psychiatry Journal, 2*(1), 30-36. doi:10.2174/1874354400802010030

Adkinson, B., Kolobaric, A., Flynn, M., Dowiak, C., Schleifer, C., Santamauro, N., . . . Anticevic, A. (2018). T18. Characterizing reward responsiveness in obsessive-compulsive disorder and schizophrenia through a probabilistic reward task. *Biological Psychiatry, 83*(9), S135. doi:10.1016/j.biopsych.2018.02.354

Ahearn, D. J., McDonald, K., Barraclough, M., & Leroi, I. (2012). An exploration of apathy and impulsivity in Parkinson disease. *Current gerontology and geriatrics research, 2012*, 390701-390701. doi:10.1155/2012/390701

Allom, V., Panetta, G., Mullan, B., & Hagger, M. S. (2016). Self-report and behavioural approaches to the measurement of self-control: Are we assessing the same construct? *Personality and Individual Differences, 90*, 137-142. doi:10.1016/j.paid.2015.10.051

Amanzio, M., Monteverdi, S., Giordano, A., Soliveri, P., Filippi, P., & Geminiani, G. (2010). Impaired awareness of movement disorders in Parkinson's disease. *Brain and Cognition, 72*(3), 337-346. doi:10.1016/j.bandc.2009.10.011

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders : DSM-5* (5th ed.). Washington, DC: American Psychiatric Association.

Antonelli, F., Ray, N., & Strafella, A. P. (2011). Impulsivity and Parkinson's disease: More than just disinhibition. *Journal of the Neurological Sciences, 310*(1), 202-207. doi:10.1016/j.jns.2011.06.006

Antshel, K. M., Hier, B. O., & Barkley, R. A. (2014). Executive functioning theory and ADHD. In S. Goldstein & J. A. Naglieri (Eds.), *Handbook of Executive Functioning* (pp. 107-120). New York, NY: Springer.

Apaydin, H., Ahlskog, J., Parisi, J. E., Boeve, B. F., & Dickson, D. W. (2002). Parkinson disease neuropathology: Later-developing dementia and loss of the levodopa response. *Archives of Neurology, 59*(1), 102-112. doi:10.1001/archneur.59.1.102

Aquino, C. C., & Fox, S. H. (2015). Clinical spectrum of levodopa-induced complications. *Movement Disorders, 30*(1), 80-89. doi:10.1002/mds.26125

Arnulf, J., & Larsen, K. (2014). Predicting survey responses: How and why semantics shape survey statistics on organizational behaviour. *PLoS ONE, 9*(9), e106361. doi:10.1371/journal.pone.0106361

Ascherio, A., & Schwarzschild, M. A. (2016). The epidemiology of Parkinson's disease: Risk factors and prevention. *The Lancet Neurology, 15*(12), 1257-1272. doi:10.1016/S1474-4422(16)30230-7

Ashenhurst, J. R., Jentsch, J. D., & Ray, L. A. (2011). Risk-taking and alcohol use disorders symptomatology in a sample of problem drinkers. *Experimental and Clinical Psychopharmacology, 19*(5), 361-370. doi:10.1037/a0024412

Avanzi, M., Baratti, M., Cabrini, S., Uber, E., Brighetti, G., & Bonfà, F. (2008). The thrill of reckless driving in patients with Parkinson's disease: An additional behavioural phenomenon in dopamine dysregulation syndrome? *Parkinsonism & Related Disorders, 14*(3), 257-258. doi:10.1016/j.parkreldis.2007.04.006

Averbeck, B. B., O'Sullivan, S. S., & Djamshidian, A. (2014). Impulsive and compulsive behaviours in Parkinson's disease. *Annual review of clinical psychology, 10*, 553-580. doi:10.1146/annurev-clinpsy-032813-153705

Balconi, M., Angioletti, L., Siri, C., Meucci, N., & Pezzoli, G. (2018). Gambling behavior in Parkinson's Disease: Impulsivity, reward mechanism and cortical brain oscillations. *Psychiatry Research, 270*, 974-980. doi:10.1016/j.psychres.2018.03.041

Bang, J., Spina, S., & Miller, B. L. (2015). Frontotemporal dementia. *The Lancet, 386*(10004), 1672-1682. doi:10.1016/S0140-6736(15)00461-4

Baradaran, N., Tan, S. N., Liu, A., Ashoori, A., Palmer, S. J., Wang, Z. J., . . . McKeown, M. J. (2013). Parkinson's disease rigidity: Relation to brain connectivity and motor performance. *Frontiers in Neurology, 4*. doi:10.3389/fneur.2013.00067

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin, 121*(1), 65-94. doi:10.1037/0033-2909.121.1.65

Barone, P. (2010). Neurotransmission in Parkinson's disease: beyond dopamine. *European Journal of Neurology, 17*(3), 364-376. doi:10.1111/j.1468-1331.2009.02900.x

Barratt, E. S. (1959). Anxiety and impulsiveness related to psychomotor efficiency. *Perceptual and Motor Skills, 9*, 191-198.

Barratt, E. S. (1993). Impulsivity: Integrating cognitive, behavioral, biological and environmental data. In W. McCowan, J. Johnson, & M. Shure (Eds.), *The impulsive client: Theory, research, and treatment* (pp. 39-56).

Baumann-Vogel, H., Valko, P. O., Eisele, G., & Baumann, C. R. (2015). Impulse control disorders in Parkinson's disease: Don't set your mind at rest by self-assessments. *European Journal of Neurology, 22*(4), 603-609. doi:10.1111/ene.12646

Beach, T. G., White, C. L., Hladik, C. L., Sabbagh, M. N., Connor, D. J., Shill, H. A., . . . Adler, C. H. (2008). Olfactory bulb α-synucleinopathy has high specificity and sensitivity for Lewy body disorders. *Acta Neuropathologica, 117*(2), 169. doi:10.1007/s00401-008-0450-7

Beaulieu-Boire, I., & Lang, A. E. (2015). Behavioral effects of levodopa. *Movement Disorders, 30*(1), 90-102. doi:10.1002/mds.26121

Bechara, A. (2005). Decision making, impulse control and loss of willpower to resist drugs: a neurocognitive perspective. *Nature Neuroscience, 8*(11), 1458. doi:10.1038/nn1584

Bechara, A. (2007). *Iowa gambling task professional manual.*: Lutz: Psychological Assessment Resources.

Bechara, A., Damasio, H., Tranel, D., & Damasio, A. (1997). Deciding advantageously before knowing the advantageous strategy. *Science, 275*(5304), 1293-1295. doi:10.1126/science.275.5304.1293

Beck, A. T., Baruch, E., Balter, J. M., Steer, R. A., & Warman, D. M. (2004). A new instrument for measuring insight: the Beck Cognitive Insight Scale. *Schizophrenia Research, 68*(2–3), 319-329. doi:10.1016/S0920-9964(03)00189-0

Bellou, V., Belbasis, L., Tzoulaki, I., Evangelou, E., & Ioannidis, J. P. A. (2016). Environmental risk factors and Parkinson's disease: An umbrella review of meta-analyses. *Parkinsonism & Related Disorders, 23*, 1-9. doi:10.1016/j.parkreldis.2015.12.008

Bendor, J. T., Logan, T. P., & Edwards, R. H. (2013). The Function of α-Synuclein. *Neuron, 79*(6), 1044-1066. doi:10.1016/j.neuron.2013.09.004

Benninger, D. H., Thees, S., Kollias, S. S., Bassetti, C. L., & Waldvogel, D. (2009). Morphological differences in Parkinson’s disease with and without rest tremor. *Journal of Neurology, 256*(2), 256-263. doi:10.1007/s00415-009-0092-2

Bentivoglio, A. R., Baldonero, E., Ricciardi, L., De Nigris, F., & Daniele, A. (2013). Neuropsychological features of patients with Parkinson's disease and impulse control

disorders. *Neurological Sciences, 34*(7), 1207-1213. doi:10.1007/s10072-012-1224-5

Berardelli, A., Rothwell, J. C., Thompson, P. D., & Hallett, M. (2001). Pathophysiology of bradykinesia in Parkinson's disease. *Brain, 124*(11), 2131-2146. doi:10.1093/brain/124.11.2131

Berridge, K. C., Robinson, T. E., & Aldridge, J. W. (2009). Dissecting components of reward: 'liking', 'wanting', and learning. *Current opinion in pharmacology, 9*(1), 65-73. doi:10.1016/j.coph.2008.12.014

Best, M., Williams, J. M., & Coccaro, E. F. (2002). Evidence for a dysfunctional prefrontal circuit in patients with an impulsive aggressive disorder. *Proceedings of the National Academy of Sciences of the United States of America, 99*(12), 8448-8453. doi:10.1073/pnas.112604099

Biars, J. W., Nespeca, M., Busch, R. M., Kubu, C. S., Floden, D. P., & Johnson, N. L. (2018). Iowa gambling task performance in Parkinson Disease patients with impulse control disorders. *Archives of Clinical Neuropsychology, 34*(3), 310-318. doi:10.1093/arclin/acy036

Bickel, W. K., Jarmolowicz, D. P., Mueller, E. T., Gatchalian, K. M., & McClure, S. M. (2012). Are executive function and impulsivity antipodes? A conceptual reconstruction with special reference to addiction. *Psychopharmacology, 221*(3), 361-387. doi:10.1007/s00213-012-2689-x

Bienfait, K. L., Menza, M., Mark, M. H., & Dobkin, R. D. (2010). Impulsive smoking in a patient with Parkinson's disease treated with dopamine agonists. *Journal of Clinical Neuroscience, 17*(4), 539-540. doi:10.1016/j.jocn.2009.09.001

Bjornestad, P. A., Tysnes, P. O.-B., Larsen, P. J., & Alves, P. G. (2016). Loss of independence in early Parkinson disease: A 5-year population-based incident cohort study. *Neurology, 87*(15), 1599-1606. doi:10.1212/WNL.0000000000003213

Black, D. W. (2014). *DSM-5® guidebook: The essential companion to the diagnostic and statistical manual of mental disorders, fifth edition*. Washington, D.C: American Psychiatric Publishing.

Blandini, F., Nappi, G., Tassorelli, C., & Martignoni, E. (2000). Functional changes of the basal ganglia circuitry in Parkinson's disease. *Progress in Neurobiology, 62*(1), 63-88. doi:10.1016/S0301-0082(99)00067-2

Bloomfield, J., Woods, D., & Ludington, J. (2016). Self-awareness of memory impairment in Parkinson's disease: A review of the literature. *Working with Older People, 20*(1), 57-64. doi:10.1108/WWOP-08-2015-0019

Boettiger, C. A., Mitchell, J. M., Tavares, V. C., Robertson, M., Joslyn, G., D'Esposito, M., & Fields, H. L. (2007). Immediate reward bias in humans: fronto-parietal networks

and a role for the catechol-O-methyltransferase 158(Val/Val) genotype. *The Journal of Neuroscience, 27*(52), 14383-14391. doi:10.1523/jneurosci.2551-07.2007

Bogdan, R., & Pizzagalli, D. A. (2006). Acute stress reduces reward responsiveness: Implications for depression. *Biological Psychiatry, 60*(10), 1147-1154. doi:10.1016/j.biopsych.2006.03.037

Bohnen, N. I., & Albin, R. L. (2011). The cholinergic system and Parkinson disease. *Behavioural Brain Research, 221*(2), 564-573. doi:10.1016/j.bbr.2009.12.048

Bohnen, N. I., Kaufer, D. I., Hendrickson, R., Ivanco, L. S., Lopresti, B. J., Constantine, G. M., . . . DeKosky, S. T. (2006). Cognitive correlates of corticalcholinergic denervation in Parkinson's disease and parkinsonian dementia. *Journal of Neurology, 253*(2), 242-247. doi:10.1007/s00415-005-0971-0

Bohnen, N. I., Müller, M. L. T. M., Kotagal, V., Koeppe, R. A., Kilbourn, M. R., Gilman, S., . . . Frey, K. A. (2012). Heterogeneity of cholinergic denervation in Parkinson's disease without dementia. *Journal of Cerebral Blood Flow & Metabolism, 32*(8), 1609-1617. doi:10.1038/jcbfm.2012.60

Boksem, M. A. S., Tops, M., Wester, A. E., Meijman, T. F., & Lorist, M. M. (2006). Error-related ERP components and individual differences in punishment and reward sensitivity. *Brain Research, 1101*(1), 92-101. doi:10.1016/j.brainres.2006.05.004

Bonini, N. M., & Giasson, B. I. (2005). Snaring the Function of α-Synuclein. *Cell, 123*(3), 359-361. doi:10.1016/j.cell.2005.10.017

Bonuccelli, U., Del Dotto, P., & Rascol, O. (2009). Role of dopamine receptor agonists in the treatment of early Parkinson's disease. *Parkinsonism & Related Disorders, 15*, S44-S53. doi:10.1016/S1353-8020(09)70835-1

Bora, E. (2017). Relationship between insight and theory of mind in schizophrenia: A meta-analysis. *Schizophrenia Research, 190*, 11-17. doi:10.1016/j.schres.2017.03.029

Bora, E., Walterfang, M., & Velakoulis, D. (2015). Theory of mind in Parkinson's disease: A meta-analysis. *Behavioural Brain Research, 292*, 515-520. doi:10.1016/j.bbr.2015.07.012

Borland, R., Yong, H.-H., O'Connor, R. J., Hyland, A., & Thompson, M. E. (2010). The reliability and predictive validity of the Heaviness of Smoking Index and its two components: Findings from the International Tobacco Control Four Country study. *Nicotine & Tobacco Research, 12*(suppl 1), S45-S50. doi:10.1093/ntr/ntq038

Bower, J. H., Grossardt, B. R., Maraganore, D. M., Ahlskog, J. E., Colligan, R. C., Geda, Y. E., . . . Rocca, W. A. (2010). Anxious personality predicts an increased risk of Parkinson's disease. *Movement Disorders, 25*(13), 2105-2113. doi:10.1002/mds.23230

Bowman, C. H., & Turnbull, O. H. (2003). Real versus facsimile reinforcers on the Iowa Gambling Task. *Brain and Cognition, 53*(2), 207-210. doi:10.1016/S0278-2626(03)00111-8

Braak, H., & Del Tredici, K. (2008). Cortico-basal ganglia-cortical circuitry in Parkinson's disease reconsidered. *Experimental Neurology, 212*(1), 226-229. doi:10.1016/j.expneurol.2008.04.001

Braak, H., Del Tredici, K., Rüb, U., de Vos, R. A., Jansen Steur, E. N., & Braak, E. (2003). Staging of brain pathology related to sporadic Parkinson's disease. *Neurobiology of Aging, 24*(2), 197-211. doi:10.1016/S0197-4580(02)00065-9

Braak, H., Ghebremedhin, E., Rüb, U., Bratzke, H., & Del Tredici, K. (2004). Stages in the development of Parkinson's disease-related pathology. *Cell and Tissue Research, 318*(1), 121-134. doi:10.1007/s00441-004-0956-9

Braak, H., Rüb, U., Gai, W. P., & Del Tredici, K. (2003). Idiopathic Parkinson's disease: possible routes by which vulnerable neuronal types may be subject to neuroinvasion by an unknown pathogen. *Journal of Neural Transmission, 110*(5), 517-536. doi:10.1007/s00702-002-0808-2

Braddock, K. H., Dillard, J. P., Voigt, D. C., Stephenson, M. T., Sopory, P., & Anderson, J. W. (2011). Impulsivity partially mediates the relationship between BIS/BAS and risky health behaviors. *Journal of Personality, 79*(4), 793-810. doi:10.1111/j.1467-6494.2011.00699.x

Bradley, K. A., DeBenedetti, A. F., Volk, R. J., Williams, E. C., Frank, D., & Kivlahan, D. R. (2007). AUDIT-C as a brief screen for alcohol misuse in primary care. *Alcoholism: Clinical and Experimental Research, 31*(7), 1208-1217. doi:10.1111/j.1530-0277.2007.00403.x

Brandt, J., Spencer, M., & Folstein, M. (1988). The telephone interview for cognitive status. *Neuropsychiatry, Neuropsychology and Behavioral Neurology, 1*(2), 111-117. Retrieved from https://psycnet.apa.org/

Brener, N. D., Kann, L., McManus, T., Kinchen, S. A., Sundberg, E. C., & Ross, J. G. (2002). Reliability of the 1999 youth risk behavior survey questionnaire. *Journal of Adolescent Health, 31*(4), 336-342. doi:10.1016/S1054-139X(02)00339-7

Brevers, D., Cleeremans, A., Bechara, A., Greisen, M., Kornreich, C., Verbanck, P., & Noël, X. (2013). Impaired self-awareness in pathological gamblers. *Journal of Gambling Studies, 29*(1), 119-129. doi:10.1007/s10899-012-9292-2

Brevers, D., Cleeremans, A., Bechara, A., Greisen, M., Kornreich, C., Verbanck, P., & Noël, X. (2014). Impaired metacognitive capacities in individuals with problem gambling. *Journal of Gambling Studies, 30*(1), 141-152. doi:10.1007/s10899-012-9348-3

Brichta, L., Greengard, P., & Flajolet, M. (2013). Advances in the pharmacological treatment of Parkinson's disease: targeting neurotransmitter systems. *Trends in Neurosciences, 36*(9), 543-554. doi:10.1016/j.tins.2013.06.003

Broen, M. P. G., Narayen, N. E., Kuijf, M. L., Dissanayaka, N. N. W., & Leentjens, A. F. G. (2016). Prevalence of anxiety in Parkinson's disease: A systematic review and meta-analysis. *Movement Disorders, 31*(8), 1125-1133. doi:10.1002/mds.26643

Bruno, V., Mancini, D., Ghoche, R., Arshinoff, R., & Miyasaki, J. M. (2016). High prevalence of physical and sexual aggression to caregivers in advanced Parkinson's disease. Experience in the Palliative Care Program. *Parkinsonism & Related Disorders, 24*, 141-142. doi:10.1016/j.parkreldis.2016.01.010

Buchy, L., Barbato, M., MacMaster, F. P., Bray, S., Clark, D., Deighton, S., & Addington, J. (2016). Cognitive insight is associated with cortical thickness in first-episode psychosis. *Schizophrenia Research, 172*(1), 16-22. doi:10.1016/j.schres.2016.02.026

Buchy, L., Brodeur, M. B., & Lepage, M. (2012). The Beck Cognitive Insight Scale: Psychometric properties in a Canadian community sample. *Schizophrenia Research, 137*(1–3), 254-255. doi:10.1016/j.schres.2012.02.020

Buchy, L., Hawco, C., Bodnar, M., Izadi, S., Dell'Elce, J., Messina, K., & Lepage, M. (2014). Functional magnetic resonance imaging study of external source memory and its relation to cognitive insight in non-clinical subjects. *Psychiatry and Clinical Neurosciences, 68*(9), 683-691. doi:10.1111/pcn.12177

Buelow, M. T., & Barnhart, W. R. (2018). Test–retest reliability of common behavioral decision making tasks. *Archives of Clinical Neuropsychology, 33*(1), 125-129. doi:10.1093/arclin/acx038

Buelow, M. T., Frakey, L. L., Grace, J., & Friedman, J. H. (2014). The contribution of apathy and increased learning trials to risky decision-making in Parkinson's disease. *Archives of Clinical Neuropsychology, 29*(1), 100-109. doi:10.1093/arclin/act065

Buelow, M. T., & Suhr, J. (2009). Construct validity of the Iowa Gambling Task. *Neuropsychology Review, 19*(1), 102-114. doi:10.1007/s11065-009-9083-4

Bühler, M., & Mann, K. (2011). Alcohol and the human brain: A systematic review of different neuroimaging methods. *Alcoholism: Clinical and Experimental Research, 35*(10), 1771-1793. doi:10.1111/j.1530-0277.2011.01540.x

Bunford, N., Brandt, N., Golden, C., Dykstra, J., Suhr, J., & Owens, J. (2015). Attention-Deficit/Hyperactivity Disorder symptoms mediate the association between deficits in executive functioning and social impairment in children. *An official publication of the International Society for Research in Child and Adolescent Psychopathology, 43*(1), 133-147. doi:10.1007/s10802-014-9902-9

Burdick, J. D., Roy, A. L., & Raver, C. C. (2013). Evaluating the Iowa Gambling Task as a direct assessment of impulsivity with low-income children. *Personality and Individual Differences, 55*(7), 771-776. doi:10.1016/j.paid.2013.06.009

Callesen, M. B., & Damholdt, M. F. (2017). Phenomenology and gender characteristics of hobbyism and punding in Parkinson's disease: A self-report study. *Basal Ganglia, 9*, 1-6. doi:10.1016/j.baga.2017.06.002

Callesen, M. B., Scheel-Krueger, J., Kringelbach, M. L., & Moller, A. (2013). A systematic review of impulse control disorders in Parkinson's disease. *Journal of Parkinson's Disease, 3*, 105-138. doi:10.3233/JPD-120165

Campbell, A., & Muncer, S. (2009). Can 'risky' impulsivity explain sex differences in aggression? *Personality and Individual Differences, 47*(5), 402-406. doi:10.1016/j.paid.2009.04.006

Campbell, J. A., Samartgis, J. R., & Crowe, S. F. (2013). Impaired decision making on the Balloon Analogue Risk Task as a result of long-term alcohol use. *Journal of Clinical and Experimental Neuropsychology, 35*(10), 1071-1081. doi:10.1080/13803395.2013.856382

Cardoso, C. D. O., Carvalho, J. C. N., Cotrena, C., Bakos, D. D. G. S., Kristensen, C. H., & Fonseca, R. P. (2010). Reliability study of the neuropsychological test Iowa Gambling Task. *Jornal Brasileiro de Psiquiatria, 59*(4), 279-285.

Carmona, S., Proal, E., Hoekzema, E. A., Gispert, J.-D., Picado, M., Moreno, I., . . . Vilarroya, O. (2009). Ventro-striatal reductions underpin symptoms of hyperactivity and impulsivity in attention-deficit/hyperactivity disorder. *Biological Psychiatry, 66*(10), 972-977. doi:10.1016/j.biopsych.2009.05.013

Carver, C. S. (2005). Impulse and constraint: Perspectives from personality psychology, convergence with theory in other areas, and potential for integration. *Personality and Social Psychology Review, 9*(4), 312-333. doi:10.1207/s15327957pspr0904_2

Carver, C. S., & White, T. (1994). Behavioral-inhibition, behavioral activation, and affective responses to impending reward and punishment - The BIS BAS scales. *Journal of Personality and Social Psychology, 67*(2), 319-333.

Castrioto, A., Funkiewiez, A., Debû, B., Cools, R., Lhommée, E., Ardouin, C., . . . Krack, P. (2015). Iowa gambling task impairment in Parkinson's disease can be normalised by reduction of dopaminergic medication after subthalamic stimulation. *Journal of Neurology, Neurosurgery & Psychiatry, 86*(2), 186. doi:10.1136/jnnp-2013-307146

Centers for Disease Control and Prevention. (2015). *Youth Risk Behavior Surveillance System*. Atlanta GA: Centers for Disease Control and Prevention

Cersosimo, M. G., & Benarroch, E. E. (2008). Neural control of the gastrointestinal tract: Implications for Parkinson disease. *Movement Disorders, 23*(8), 1065-1075. doi:10.1002/mds.22051

Cersosimo, M. G., & Benarroch, E. E. (2012). Pathological correlates of gastrointestinal dysfunction in Parkinson's disease. *Neurobiology of Disease, 46*(3), 559-564. doi:10.1016/j.nbd.2011.10.014

Cersosimo, M. G., Raina, G. B., Pecci, C., Pellene, A., Calandra, C. R., Gutiérrez, C., . . . Benarroch, E. E. (2013). Gastrointestinal manifestations in Parkinson's disease: prevalence and occurrence before motor symptoms. *Journal of Neurology, 260*(5), 1332-1338. doi:10.1007/s00415-012-6801-2

Chan, S. K. W., Chan, K. K. S., Hui, C. L., Wong, G. H. Y., Chang, W. C., Lee, E. H. M., . . . Chen, E. Y. H. (2014). Correlates of insight with symptomatology and executive function in patients with first-episode schizophrenia-spectrum disorder: A longitudinal perspective. *Psychiatry Research, 216*(2), 177-184. doi:10.1016/j.psychres.2013.11.028

Chaudhuri, K. R., Sauerbier, A., Rojo, J. M., Sethi, K., Schapira, A. H. V., Brown, R. G., . . . Martinez-Martin, P. (2015). The burden of non-motor symptoms in Parkinson's disease using a self-completed non-motor questionnaire: A simple grading system. *Parkinsonism & Related Disorders, 21*(3), 287-291. doi:10.1016/j.parkreldis.2014.12.031

Chen, J.-F., Xu, K., Petzer, J. P., Staal, R., Xu, Y.-H., Beilstein, M., . . . Schwarzschild, M. A. (2001). Neuroprotection by caffeine and a(2a) adenosine receptor inactivation in a model of Parkinson's disease. *The Journal of Neuroscience, 21*(10), RC143-RC143. doi:10.1523/JNEUROSCI.21-10-j0001.2001

Cho, H., Kwan, J.-h., & Seo, H.-j. (2008). Compulsive shopping in parkinson's disease - A case report. *Journal of Movment Disorders, 1*(2), 97-100. doi:10.14802/jmd.08019

Christenson, G. A., Faber, R. J., de Zwaan, M., Raymond, N. C., Specker, S. M., Ekern, M. D., . . . et al. (1994). Compulsive buying: Descriptive characteristics and psychiatric comorbidity. *Journal of Clinical Psychiatry, 55*(1), 5-11.

Chung, C. L., & Mak, M. K. Y. (2016). Effect of repetitive transcranial magnetic stimulation on physical function and motor signs in parkinson's disease: A systematic review and meta-analysis. *Brain Stimulation, 9*(4), 475-487. doi:10.1016/j.brs.2016.03.017

Claassen, D. O., Josephs, K. A., Ahlskog, J. E., Silber, M. H., Tippmann-Peikert, M., & Boeve, B. F. (2010). REM sleep behavior disorder preceding other aspects of synucleinopathies by up to half a century. *Neurology, 75*(6), 494-499. doi:10.1212/WNL.0b013e3181ec7fac

Claassen, D. O., Stark, A. J., Spears, C. A., Petersen, K. J., van Wouwe, N. C., Kessler, R. M., . . . Donahue, M. J. (2017). Mesocorticolimbic hemodynamic response in Parkinson's disease patients with compulsive behaviors. *Movement Disorders, 32*(11), 1574-1583. doi:10.1002/mds.27047

Claassen, D. O., Van Den Wildenberg, W. P. M., Ridderinkhof, K. R., Jessup, C. K., Harrison, M. B., Wooten, G. F., & Wylie, S. A. (2011). The risky business of dopamine agonists in Parkinson disease and impulse control disorders. *Behavioral Neuroscience, 125*(4), 492-500. doi:10.1037/a0023795

Clark, C. A., & Dagher, A. (2014). The role of dopamine in risk taking: a specific look at Parkinson's disease and gambling. *Frontiers in Behavioral Neuroscience, 8*(196). doi:10.3389/fnbeh.2014.00196

Cools, R. (2006). Dopaminergic modulation of cognitive function-implications for L-DOPA treatment in Parkinson's disease. *Neuroscience & Biobehavioral Reviews, 30*(1), 1-23. doi:10.1016/j.neubiorev.2005.03.024

Cools, R., Altamirano, L., & D'Esposito, M. (2006). Reversal learning in Parkinson's disease depends on medication status and outcome valence. *Neuropsychologia, 44*(10), 1663-1673. doi:10.1016/j.neuropsychologia.2006.03.030

Cortese, S., Kelly, C., Chabernaud, C., Proal, E., Di Martino, A., Milham, M. P., & Castellanos, F. X. (2012). Toward systems neuroscience of ADHD: A meta-analysis of 55 fMRI studies. *American Journal of Psychiatry, 169*(10), 1038-1055. doi:10.1176/appi.ajp.2012.11101521

Corvol, J.-C., Artaud, F., Cormier-Dequaire, F., Rascol, O., Durif, F., Derkinderen, P., . . . Elbaz, A. (2018). Longitudinal analysis of impulse control disorders in Parkinson disease. *Neurology, 91*(3), e189. doi:10.1212/WNL.0000000000005816

Cossu, G., Rinaldi, R., & Colosimo, C. (2018). The rise and fall of impulse control behavior disorders. *Parkinsonism & Related Disorders, 46*, S24-S29. doi:10.1016/j.parkreldis.2017.07.030

Crews, F. T., & Boettiger, C. A. (2009). Impulsivity, frontal lobes and risk for addiction. *Pharmacology, biochemistry, and behavior, 93*(3), 237-247. doi:10.1016/j.pbb.2009.04.018

Cross, C. P., Copping, L., & Campbell, A. (2011). Sex differences in impulsivity: A meta-analysis. *Psychological Bulletin, 137*(1), 97-130. doi:10.1037/a0021591

Crowley, T. J., Raymond, K. M., Mikulich-Gilbertson, S. K., Thompson, L. L., & Lejuez, C. W. (2006). A risk-taking "set" in a novel task among adolescents with serious conduct and substance problems. *Journal of the American Academy of Child & Adolescent Psychiatry, 45*(2), 175-183. doi:10.1097/01.chi.0000188893.60551.31

Cyders, M. A., & Coskunpinar, A. (2011). Measurement of constructs using self-report and behavioral lab tasks: Is there overlap in nomothetic span and construct representation for impulsivity? *Clinical Psychology Review, 31*(6), 965-982. doi:10.1016/j.cpr.2011.06.001

Dagher, A., & Robbins, T. W. (2009). Personality, addiction, dopamine: Insights from Parkinson's disease. *Neuron, 61*(4), 502-510. doi:10.1016/j.neuron.2009.01.031

Daniel, R., & Pollmann, S. (2014). A universal role of the ventral striatum in reward-based learning: Evidence from human studies. *Neurobiology of Learning and Memory, 114*, 90-100. doi:10.1016/j.nlm.2014.05.002

David, A. S., Bedford, N., Wiffen, B., & Gilleen, J. (2012). Failures of metacognition and lack of insight in neuropsychiatric disorders. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences, 367*(1594), 1379-1390. doi:10.1098/rstb.2012.0002

Davis-Gahagen, H. I. (2014). *Meta-analysis of the validity of the balloon analogue risk task.* Ohio University,

Dawson, A., Dissanayaka, N. N., Evans, A., Verdejo-Garcia, A., Chong, T. T. J., Frazzitta, G., . . . Carter, A. (2018). Neurocognitive correlates of medication-induced addictive behaviours in Parkinson's disease: A systematic review. *European Neuropsychopharmacology, 28*(5), 561-578. doi:10.1016/j.euroneuro.2018.03.012

de Ridder, D. T., Lensvelt-Mulders, G., Finkenauer, C., Stok, F. M., & Baumeister, R. F. (2011). Taking stock of self-control: A meta-analysis of how trait self-control relates to a wide range of behaviors. *Personality and Social Psychology Review, 16*(1), 76-99. doi:10.1177/1088868311418749

de Wit, H. (2009). Impulsivity as a determinant and consequence of drug use: A review of underlying processes. *Addiction Biology, 14*(1), 22-31. doi:10.1111/j.1369-1600.2008.00129.x

Dean, A. C., Sugar, C. A., Hellemann, G., & London, E. D. (2011). Is all risk bad? Young adult cigarette smokers fail to take adaptive risk in a laboratory decision-making test. *Psychopharmacology, 215*(4), 801-811. doi:10.1007/s00213-011-2182-y

Degirmenci, E., Degirmenci, T., Düğüncü, Y., & Yılmaz, G. (2013). Cognitive insight in Alzheimer's disease. *American Journal of Alzheimer's Disease & Other Dementias, 28*(3), 263-268. doi:10.1177/1533317513481089

Del Tredici, K., & Braak, H. (2012). Lewy pathology and neurodegeneration in premotor Parkinson's disease. *Movement Disorders, 27*(5), 597-607. doi:10.1002/mds.24921

Del Tredici, K., & Braak, H. (2013). Dysfunction of the locus coeruleus–norepinephrine system and related circuitry in Parkinson's disease-related dementia. *Journal of Neurology, Neurosurgery & Psychiatry, 84*(7), 774. doi:10.1136/jnnp-2011-301817

Deloitte Access Economics. (2015). *Living with Parkinson's Disease An updated economic analysis 2014*. Retrieved from https://www2.deloitte.com/

DeLong, M., & Wichmann, T. (2009). Update on models of basal ganglia function and dysfunction. *Parkinsonism & Related Disorders, 15*(S3), S237-S240. doi:10.1016/S1353-8020(09)70822-3

den Brok Melina, G. H. E., van Dalen Jan, W., van Gool Willem, A., Moll van Charante Eric, P., de Bie Rob, M. A., & Richard, E. (2015). Apathy in Parkinson's disease: A systematic review and meta-analysis. *Movement Disorders, 30*(6), 759-769. doi:10.1002/mds.26208

Derkinderen, P., Shannon, K. M., & Brundin, P. (2014). Gut feelings about smoking and coffee in Parkinson's disease. *Movement Disorders, 29*(8), 976-979. doi:10.1002/mds.25882

Desmarais, P., Lanctôt, K., Masellis, M., Black, S., & Herrmann, N. (2018). Social inappropriateness in neurodegenerative disorders. *International Psychogeriatrics, 30*(2), 197-207. doi:10.1017/S1041610217001260

Desmond, D. W., Tatemichi, T. K., & Hanzawa, L. (1994). The Telephone Interview for Cognitive Status (TICS): Reliability and validity in a stroke sample. *International Journal of Geriatric Psychiatry, 9*(10), 803-807. doi:10.1002/gps.930091006

Deuschl, G., Schade-Brittinger, C., Krack, P., Volkmann, J., Schäfer, H., Bötzel, K., . . . Voges, J. (2006). A randomized trial of deep-brain stimulation for Parkinson's disease. *New England Journal of Medicine, 355*(9), 896-908. doi:10.1056/NEJMoa060281

Dichter, G. S., Felder, J. N., Petty, C., Bizzell, J., Ernst, M., & Smoski, M. J. (2009). The effects of psychotherapy on neural responses to rewards in major depression. *Biological Psychiatry, 66*(9), 886-897. doi:10.1016/j.biopsych.2009.06.021

Dick, D. M., Smith, G., Olausson, P., Mitchell, S. H., Leeman, R. F., O'Malley, S. S., & Sher, K. (2010). Understanding the construct of impulsivity and its relationship to alcohol use disorders. *Addiction Biology, 15*(2), 217-226. doi:10.1111/j.1369-1600.2009.00190.x

Dickson, D. W. (2017). Neuropathology of Parkinson disease. *Parkinsonism & Related Disorders*. doi:10.1016/j.parkreldis.2017.07.033

Dickson, D. W., Braak, H., Duda, J. E., Duyckaerts, C., Gasser, T., Halliday, G. M., . . . Litvan, I. (2009). Neuropathological assessment of Parkinson's disease: refining the diagnostic criteria. *The Lancet Neurology, 8*(12), 1150-1157. doi:10.1016/S1474-4422(09)70238-8

Dickson, D. W., Fujishiro, H., Orr, C., DelleDonne, A., Josephs, K. A., Frigerio, R., . . . Ahlskog, J. E. (2009). Neuropathology of non-motor features of Parkinson disease.

Parkinsonism & Related Disorders, 15(S3), S1-S5. doi:10.1016/S1353-8020(09)70769-2

Diekhof, E. K., & Gruber, O. (2010). When desire collides with reason: Functional interactions between anteroventral prefrontal cortex and nucleus accumbens underlie the human ability to resist impulsive desires. *The Journal of Neuroscience, 30*(4), 1488. doi:10.1523/JNEUROSCI.4690-09.2010

Djamshidian, A., Averbeck, B. B., Lees, A. J., & O'Sullivan, S. S. (2011). Clinical aspects of impulsive compulsive behaviours in Parkinson's disease. *Journal of the Neurological Sciences, 310*(1–2), 183-188. doi:10.1016/j.jns.2011.07.031

Dobkin, R. D., Menza, M., Allen, L. A., Gara, M. A., Mark, M. H., Tiu, J., . . . Friedman, J. (2011). Cognitive-behavioral therapy for depression in Parkinson's disease: A randomized, controlled trial. *American Journal of Psychiatry, 168*(10), 1066-1074. doi:10.1176/appi.ajp.2011.10111669

Dodd, M., Klos, K. J., Bower, J. H., Geda, Y. E., Josephs, K. A., & Ahlskog, J. (2005). Pathological gambling caused by drugs used to treat parkinson disease. *Archives of Neurology, 62*(9), 1377-1381. doi:10.1001/archneur.62.9.noc50009

Dorsey, E., Constantinescu, R., Thompson, J. P., Biglan, K., Holloway, R. G., Kieburtz, K., . . . Tanner, C. M. (2006). Projected number of people with Parkinson's disease in the most populous nations, 2005-2030. *Movement Disorders, 21*, S483-S483.

Doty, R. L. (2012a). Olfaction in Parkinson's disease and related disorders. *Neurobiology of Disease, 46*(3), 527-552. doi:10.1016/j.nbd.2011.10.026

Doty, R. L. (2012b). Olfactory dysfunction in Parkinson disease. *Nature Reviews Neurology, 8*(6), 329-339. doi:10.1038/nrneurol.2012.80

Dougherty, D., Mathias, C., Marsh, D., & Jagar, A. (2005). Laboratory behavioral measures of impulsivity. *Behavior Research Methods, 37*(1), 82-90. doi:10.3758/bf03206401

Duckworth, A. L., & Kern, M. L. (2011). A meta-analysis of the convergent validity of self-control measures. *Journal of Research in Personality, 45*(3), 259-268. doi:10.1016/j.jrp.2011.02.004

Dugger, B. N., & Dickson, D. W. (2010). Cell type specific sequestration of choline acetyltransferase and tyrosine hydroxylase within Lewy bodies. *Acta Neuropathologica, 120*(5), 633-639. doi:10.1007/s00401-010-0739-1

Egan, S. J., Laidlaw, K., & Starkstein, S. (2015). Cognitive behaviour therapy for depression and anxiety in Parkinson’s disease. *Journal of Parkinson's Disease, 5*(3), 443-451. doi:10.3233/JPD-150542

Eisenberg, D. P., & Berman, K. F. (2009). Executive function, neural circuitry, and genetic mechanisms in schizophrenia. *Neuropsychopharmacology, 35*(1), 258. doi:10.1038/npp.2009.111

Elbaz, A., Bower, J. H., Maraganore, D. M., McDonnell, S. K., Peterson, B. J., Ahlskog, J. E., . . . Rocca, W. A. (2002). Risk tables for parkinsonism and Parkinson's disease. *Journal of Clinical Epidemiology, 55*(1), 25-31. doi:10.1016/S0895-4356(01)00425-5

Elbaz, A., Carcaillon, L., Kab, S., & Moisan, F. (2016). Epidemiology of Parkinson's disease. *Revue Neurologique, 172*(1), 14-26. doi:10.1016/j.neurol.2015.09.012

Elbaz, A., Clavel, J., Rathouz, P. J., Moisan, F., Galanaud, J. P., Delemotte, B., . . . Tzourio, C. (2009). Professional exposure to pesticides and Parkinson disease. *Annals of Neurology, 66*(4), 494-504. doi:10.1002/ana.21717

Elizabeth, E. S., Ronald, K., Josiah, R. B., Ilana, B. W., Karl, D., & Patricia, H. J. (2013). A causal link between prediction errors, dopamine neurons and learning. *Nature Neuroscience, 16*(7), 966. doi:10.1038/nn.3413

Ellis, J. M., & Fell, M. J. (2017). Current approaches to the treatment of Parkinson's Disease. *Bioorganic & Medicinal Chemistry Letters, 27*(18), 4247-4255. doi:10.1016/j.bmcl.2017.07.075

Elmer, L., & Hauser, R. A. (2011). Strategies for Parkinson's disease care: Prevention and management of motor fluctuations. *Neurodegenerative Disease Management, 1*(5), 415-430. doi:10.1016/j.parkreldis.2011.02.018

Emery, R. L., & Levine, M. D. (2017). Questionnaire and behavioral task measures of impulsivity are differentially associated with body mass index: A comprehensive meta-analysis. *Psychological Bulletin*. doi:10.1037/bul0000105

Emre, M., Aarsland, D., Brown, R., Burn, D. J., Duyckaerts, C., Mizuno, Y., . . . Dubois, B. (2007). Clinical diagnostic criteria for dementia associated with Parkinson's disease. *Movement Disorders, 22*(12), 1689-1707. doi:10.1002/mds.21507

Enticott, P. G., & Ogloff, J. R. P. (2006). Elucidation of impulsivity. *Australian Psychologist, 41*(1), 3-14. doi:10.1080/00050060500391894

Escott-Price, V., for the International Parkinson's Disease Genomics, C., Nalls, M. A., Morris, H. R., Lubbe, S., Brice, A., . . . on behalf of the, I. c. m. (2015). Polygenic risk of Parkinson disease is correlated with disease age at onset. *Annals of Neurology, 77*(4), 582-591. doi:10.1002/ana.24335

Eskelund, K., Karstoft, K.-I., & Andersen, S. B. (2018). Anhedonia and emotional numbing in treatment-seeking veterans: Behavioural and electrophysiological responses to reward. *European journal of psychotraumatology, 9*(1), 1446616-1446616. doi:10.1080/20008198.2018.1446616

Eskow Jaunarajs, K. L., Angoa-Perez, M., Kuhn, D. M., & Bishop, C. (2011). Potential mechanisms underlying anxiety and depression in Parkinson's disease:

Consequences of l-DOPA treatment. *Neuroscience & Biobehavioral Reviews, 35*(3), 556-564. doi:10.1016/j.neubiorev.2010.06.007

Evans, A. H., Katzenschlager, R., Paviour, D., O'Sullivan, J. D., Appel, S., Lawrence, A. D., & Lees, A. J. (2004). Punding in Parkinson's disease: Its relation to the dopamine dysregulation syndrome. *Movement Disorders, 19*(4), 397-405. doi:10.1002/mds.20045

Evans, A. H., Lawrence, A. D., Potts, J., MacGregor, L., Katzenschlager, R., Shaw, K., . . . Lees, A. J. (2006). Relationship between impulsive sensation seeking traits, smoking, alcohol and caffeine intake, and Parkinson's disease. *Journal of Neurology, Neurosurgery & Psychiatry, 77*(3), 317-321. doi:10.1136/jnnp.2005.065417

Evans, A. H., Okai, D., Weintraub, D., Lim, S.-Y., O'Sullivan, S. S., Voon, V., . . . Schrag, A. (2019). Scales to assess impulsive and compulsive behaviors in Parkinson's disease: Critique and recommendations. *Movement Disorders, 34*(6), 791-798. doi:10.1002/mds.27689

Evans, A. H., Pavese, N., Lawrence, A. D., Tai, Y. F., Appel, S., Doder, M., . . . Piccini, P. (2006). Compulsive drug use linked to sensitized ventral striatal dopamine transmission. *Annals of Neurology, 59*(5), 852-858. doi:10.1002/ana.20822

Evans, A. H., Strafella, A. P., Weintraub, D., & Stacy, M. (2009). Impulsive and compulsive behaviors in Parkinson's disease. *Movement Disorders, 24*(11), 1561-1570. doi:10.1002/mds.22505

Even, C., & Weintraub, D. (2012). Is depression in Parkinson's Disease a specific entity? *Journal of Affective Disorders, 139*(2), 103-112. doi:10.1016/j.jad.2011.07.002

Evens, R., Hoefler, M., Biber, K., & Lueken, U. (2016). The Iowa Gambling Task in Parkinson's disease: A meta-analysis on effects of disease and medication. *Neuropsychologia, 91*, 163-172. doi:10.1016/j.neuropsychologia.2016.07.032

Eysenck, H. J., & Eysenck, S. B. G. (1968). *Manual of the Eysenck Personality Inventory*. London: University of London Press.

Eysenck, S. B. G., & Eysenck, H. J. (1978). Impulsiveness and Venturesomeness: Their Position in a Dimensional System of Personality Description. *Psychological Reports, 43*(3_suppl), 1247-1255. doi:10.2466/pr0.1978.43.3f.1247

Fan, W., Ding, H., Ma, J., & Chan, P. (2009). Impulse control disorders in Parkinson's disease in a Chinese population. *Neuroscience Letters, 465*(1), 6-9. doi:10.1016/j.neulet.2009.06.074

Fasano, A., Pettorruso, M., Ricciardi, L., Conte, G., & Bentivoglio, A. R. (2010). Punding in Parkinson's disease: The impact of patient's awareness on diagnosis. *Movement Disorders, 25*(9), 1297-1299. doi:10.1002/mds.23061

Ferenczi, E. A., Zalocusky, K. A., Liston, C., Grosenick, L., Warden, M. R., Amatya, D., . . . Deisseroth, K. (2016). Prefrontal cortical regulation of brainwide circuit dynamics and reward-related behavior. *Science, 351*(6268). doi:10.1126/science.aac9698

Fernández-Artamendi, S., Martínez-Loredo, V., Fernández-Hermida, J. R., & Carballo-Crespo, J. L. (2016). The Impulsive Sensation Seeking (ImpSS): Psychometric properties and predictive validity regarding substance use with Spanish adolescents. *Personality and Individual Differences, 90*(Supplement C), 163-168. doi:10.1016/j.paid.2015.11.003

Fernie, G., Cole, J. C., Goudie, A. J., & Field, M. (2010). Risk-taking but not response inhibition or delay discounting predict alcohol consumption in social drinkers. *Drug and Alcohol Dependence, 112*(1), 54-61. doi:10.1016/j.drugalcdep.2010.05.011

Fernie, G., Peeters, M., Gullo Matthew, J., Christiansen, P., Cole Jon, C., Sumnall, H., & Field, M. (2013). Multiple behavioural impulsivity tasks predict prospective alcohol involvement in adolescents. *Addiction, 108*(11), 1916-1923. doi:10.1111/add.12283

Ferrucci, L., Lungo, I., Guralnik, J., Bandinelli, S., Benvenuti, E., Salani, B., . . . Baroni, A. (1998). Is the Telephone Interview for Cognitive Status a valid alternative in persons who cannot be evaluated by the Mini Mental State Examination? *Aging Clinical and Experimental Research, 10*(4), 332-338. doi:10.1007/BF03339796

Fioravanti, M., Carlone, O., Vitale, B., Cinti, M. E., & Clare, L. (2005). A meta-analysis of cognitive deficits in adults with a diagnosis of schizophrenia. *Neuropsychology Review, 15*(2), 73-95. doi:10.1007/s11065-005-6254-9

Fitts, W., Weintraub, D., Massimo, L., Chahine, L., Chen-Plotkin, A., Duda, J. E., . . . Dahodwala, N. (2015). Caregiver report of apathy predicts dementia in Parkinson's disease. *Parkinsonism & Related Disorders, 21*(8), 992-995. doi:10.1016/j.parkreldis.2015.06.009

Fletcher, L., & Carruthers, P. (2012). Metacognition and reasoning. *Philosophical Transactions of the Royal Society, B: Biological Sciences, 367*(1594), 1366-1378. doi:10.1098/rstb.2011.0413

Fong, T. G., Fearing, M. A., Jones, R. N., Shi, P., Marcantonio, E. R., Rudolph, J. L., . . . Inouye, S. K. (2009). Telephone Interview for Cognitive Status: Creating a crosswalk with the Mini-Mental State Examination. *Alzheimer's & Dementia, 5*(6), 492-497. doi:10.1016/j.jalz.2009.02.007

Franken, I. H. A., van Strien, J. W., Nijs, I., & Muris, P. (2008). Impulsivity is associated with behavioral decision-making deficits. *Psychiatry Research, 158*(2), 155-163. doi:10.1016/j.psychres.2007.06.002

Franklin, T. R., Acton, P. D., Maldjian, J. A., Gray, J. D., Croft, J. R., Dackis, C. A., . . . Childress, A. R. (2002). Decreased gray matter concentration in the insular,

orbitofrontal, cingulate, and temporal cortices of cocaine patients. *Biological Psychiatry, 51*(2), 134-142. doi:10.1016/S0006-3223(01)01269-0

Galvan, A., & Smith, Y. (2010). Basal Ganglia. In *Encyclopedia of Movement Disorders* (pp. 113-118). Oxford: Academic Press.

Gansler, D. A., Jerram, M. W., Vannorsdall, T. D., & Schretlen, D. J. (2011a). Comparing alternative metrics to assess performance on the Iowa Gambling Task. *Journal of Clinical and Experimental Neuropsychology, 33*(9), 1040-1048. doi:10.1080/13803395.2011.596820

Gansler, D. A., Jerram, M. W., Vannorsdall, T. D., & Schretlen, D. J. (2011b). Does the Iowa Gambling Task Measure executive function? *Archives of Clinical Neuropsychology, 26*(8), 706-717. doi:10.1093/arclin/acr082

Garcia-Ruiz, P. J., Chaudhuri, K. R., & Martinez-Martin, P. (2014). Non-motor symptoms of Parkinson's disease: A review…from the past. *Journal of the Neurological Sciences, 338*(1–2), 30-33. doi:10.1016/j.jns.2014.01.002

Gatto, E. M., & Aldinio, V. (2019). Impulse control disorders in Parkinson's Disease. A brief and comprehensive review. *Frontiers in Neurology, 10*, 351-351. doi:10.3389/fneur.2019.00351

Gesi, M., Soldani, P., Giorgi, F. S., Santinami, A., Bonaccorsi, I., & Fornai, F. (2000). The role of the locus coeruleus in the development of Parkinson's disease. *Neuroscience & Biobehavioral Reviews, 24*(6), 655-668. doi:10.1016/S0149-7634(00)00028-2

Gilbert, S. J., & Burgess, P. W. (2008). Executive function. *Current Biology, 18*(3), 110-114. doi:10.1016/j.cub.2007.12.014

Gillies, G. E., Pienaar, I. S., Vohra, S., & Qamhawi, Z. (2014). Sex differences in Parkinson's disease. *Frontiers in Neuroendocrinology, 35*(3), 370-384. doi:10.1016/j.yfrne.2014.02.002

Gilman, S., Koeppe, R. A., Nan, B., Wang, C. N., Wang, X., Junck, L., . . . Bhaumik, A. (2010). Cerebral cortical and subcortical cholinergic deficits in parkinsonian syndromes. *Neurology, 74*(18), 1416-1423. doi:10.1212/WNL.0b013e3181dc1a55

Giovannoni, G., O'Sullivan, J. D., Turner, K., Manson, A. J., & Lees, A. J. L. (2000). Hedonistic homeostatic dysregulation in patients with Parkinson's disease on dopamine replacement therapies. *Journal of Neurology, Neurosurgery & Psychiatry, 68*(4), 423. doi:10.1136/jnnp.68.4.423

Gleich, T., Lorenz, R., Pöhland, L., Raufelder, D., Deserno, L., Beck, A., . . . Gallinat, J. (2015). Frontal glutamate and reward processing in adolescence and adulthood. *Brain Structure and Function, 220*(6), 3087-3099. doi:10.1007/s00429-014-0844-3

Glicksohn, J., Hadad, Y., & Ben-Yaacov, T. (2016). “Now you see me, now you don’t”: The assessment of impulsivity. *Cogent Psychology, 3*(1). doi:10.1080/23311908.2016.1242682

Goerlich-Dobre, K. S., Probst, C., Winter, L., Witt, K., Deuschl, G., Möller, B., & van Eimeren, T. (2014). Alexithymia—an independent risk factor for impulsive-compulsive disorders in Parkinson's disease. *Movement Disorders, 29*(2), 214-220. doi:10.1002/mds.25679

Goetz, C. G. (2011). The history of Parkinson's disease: Early clinical descriptions and neurological therapies. *Cold Spring Harbor Perspectives in Medicine, 1*(1). doi:10.1101/cshperspect.a008862

Goetz, C. G., Tilley, B. C., Shaftman, S. R., Stebbins, G. T., Fahn, S., Martinez-Martin, P., . . . LaPelle, N. (2008). Movement Disorder Society-sponsored revision of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS): Scale presentation and clinimetric testing results. *Movement Disorders, 23*(15), 2129-2170. doi:10.1002/mds.22340

Gomide Vasconcelos, A., Sergeant, J., Corrêa, H., Mattos, P., & Malloy-Diniz, L. (2014). When self-report diverges from performance: The usage of BIS-11 along with neuropsychological tests. *Psychiatry Research, 218*(1-2), 236-243. doi:10.1016/j.psychres.2014.03.002

Grall-Bronnec, M., Victorri-Vigneau, C., Donnio, Y., Leboucher, J., Rousselet, M., Thiabaud, E., . . . Challet-Bouju, G. (2018). Dopamine agonists and impulse control disorders: A complex association. *Drug safety, 41*(1), 19-75. doi:10.1007/s40264-017-0590-6

Grant, J. E., & Chamberlain, S. R. (2014). Impulsive action and impulsive choice across substance and behavioral addictions: Cause or consequence? *Addictive Behaviors, 39*(11), 1632-1639. doi:10.1016/j.addbeh.2014.04.022

Gratwicke, J., Jahanshahi, M., & Foltynie, T. (2015). Parkinson’s disease dementia: a neural networks perspective. *Brain, 138*(6), 1454-1476. doi:10.1093/brain/awv104

Gray, J. A. (1987). *The psychology of fear and stress* (2nd ed.). Cambridge: Cambridge University Press.

Gray, J. D., Hanna, D., Gillen, A., & Rushe, T. (2016). A closer look at Carver and White's BIS/BAS scales: Factor analysis and age group differences. *Personality and Individual Differences, 95*, 20-24. doi:10.1016/j.paid.2016.02.022

Greenfield, J. G., & Bosanquet, F. D. (1953). The brain-stem lesions in Parkinsonism. *Journal of Neurology, Neurosurgery & Psychiatry, 16*(4), 213. doi:10.1136/jnnp.16.4.213

Grey, M., Dunning, C. J., Gaspar, R., Grey, C., Brundin, P., Sparr, E., & Linse, S. (2015). Acceleration of α-synuclein aggregation by exosomes. *The Journal of Biological Chemistry, 290*(5), 2969-2982. doi:10.1074/jbc.M114.585703

Grinberg, L. T., Rueb, U., Alho, A. T. d. L., & Heinsen, H. (2010). Brainstem pathology and non-motor symptoms in PD. *Journal of the Neurological Sciences, 289*(1), 81-88. doi:10.1016/j.jns.2009.08.021

Grob, S., Pizzagalli, D. A., Dutra, S. J., Stern, J., Mörgeli, H., Milos, G., . . . Hasler, G. (2012). Dopamine-related deficit in reward learning after catecholamine depletion in unmedicated, remitted subjects with bulimia nervosa. *Neuropsychopharmacology, 37*, 1945. doi:10.1038/npp.2012.41

Grove, W. M., & Lloyd, M. (2006). Meehl's contribution to clinical versus statistical prediction. *Journal of Abnormal Psychology, 115*(2), 192-194. doi:10.1037/0021-843X.115.2.192

Haber, S. N. (2011). Neuroanatomy of Reward: A View from the Ventral Striatum. In J. A. Gottfried (Ed.), *Neurobiology of Sensation and Reward*. Hoboken: Taylor and Francis.

Haeffel, G. J., & Howard, G. S. (2010). Self-report: Psychology's four-letter word. *American Journal of Psychology, 123*(2), 181-188. doi:10.5406/amerjpsyc.123.2.0181

Haehner, A., Hummel, T., Hummel, C., Sommer, U., Junghanns, S., & Reichmann, H. (2007). Olfactory loss may be a first sign of idiopathic Parkinson's disease. *Movement Disorders, 22*(6), 839-842. doi:10.1002/mds.21413

Halliday, G. (2012). An evidence base for noradrenergic deficits in Parkinson's disease. *Movement Disorders, 27*(13), 1589-1591. doi:10.1002/mds.25202

Halliday, G., McCann, H., & Shepherd, C. (2012). Evaluation of the Braak hypothesis: how far can it explain the pathogenesis of Parkinson's disease? *Expert Review of Neurotherapeutics, 12*(6), 673-686. doi:10.1586/ern.12.47

Hattori, M., Zhang, G., & Preacher, K. J. (2017). Multiple local solutions and geomin rotation. *Multivariate Behavioral Research, 52*(6), 720-731. doi:10.1080/00273171.2017.1361312

Hawkes, C. H., Del Tredici, K., & Braak, H. (2007). Parkinson's disease: a dual-hit hypothesis. *Neuropathology and Applied Neurobiology, 33*(6), 599-614. doi:10.1111/j.1365-2990.2007.00874.x

Heatherton, T. F., Kozlowski, L. T., Frecker, R. C., Rickert, W., & Robinson, J. (1989). Measuring the heaviness of smoking: using self-reported time to the first cigarette of the day and number of cigarettes smoked per day. *British Journal of Addiction, 84*(7), 791-800. doi:10.1111/j.1360-0443.1989.tb03059.x

Helmich, R. C., Hallett, M., Deuschl, G., Toni, I., & Bloem, B. R. (2012). Cerebral causes and consequences of parkinsonian resting tremor: a tale of two circuits? *Brain, 135*(11), 3206-3226. doi:10.1093/brain/aws023

Hilker, R., Thomas, A. V., Klein, J. C., Weisenbach, S., Kalbe, E., Burghaus, L., . . . Heiss, W. D. (2005). Dementia in Parkinson disease: functional imaging of cholinergic and dopaminergic pathways. *Neurology, 65*(11), 1716-1722. doi:10.1212/01.wnl.0000191154.78131.f6

Holmes, A. J., Hollinshead, M. O., Roffman, J. L., Smoller, J. W., & Buckner, R. L. (2016). Individual differences in cognitive control circuit anatomy link sensation seeking, impulsivity, and substance use. *The Journal of Neuroscience, 36*(14), 4038. doi:10.1523/JNEUROSCI.3206-15.2016

Hopko, D. R., Lejuez, C. W., Daughters, S. B., Aklin, W. M., Osborne, A., Simmons, B. L., & Strong, D. R. (2006). Construct validity of the balloon analogue risk task (BART): Relationship with MDMA use by inner-city drug users in residential treatment. *Journal of Psychopathology and Behavioral Assessment, 28*(2), 95-101. doi:10.1007/s10862-006-7487-5

Hoptman, M. J. (2015). Impulsivity and aggression in schizophrenia: A neural circuitry perspective with implications for treatment. *CNS spectrums, 20*(3), 280-286. doi:10.1017/S1092852915000206

Hornung, J.-P. (2003). The human raphe nuclei and the serotonergic system. *Journal of Chemical Neuroanatomy, 26*(4), 331-343. doi:10.1016/j.jchemneu.2003.10.002

Housden, C. R., O'Sullivan, S. S., Joyce, E. M., Lees, A. J., & Roiser, J. P. (2010). Intact reward learning but elevated delay discounting in Parkinson's disease patients with impulsive-compulsive spectrum behaviors. *Neuropsychopharmacology : official publication of the American College of Neuropsychopharmacology, 35*(11), 2155-2164. doi:10.1038/npp.2010.84

Hrabovska, A., & Krejci, E. (2014). Reassessment of the role of the central cholinergic system. *Journal of Molecular Neuroscience, 53*(3), 352-358. doi:10.1007/s12031-013-0164-8

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural equation modeling: A multidisciplinary journal, 6*(1), 1-55. doi:10.1080/10705519909540118

Huang, H.-L., Chang, M. Y., Tang, J. S.-H., Chiu, Y.-C., & Weng, L.-C. (2009). Determinants of the discrepancy in patient- and caregiver-rated quality of life for persons with dementia. *Journal of Clinical Nursing, 18*(22), 3107-3118. doi:10.1111/j.1365-2702.2008.02537.x

Hughes, A. J., Daniel, S. E., Kilford, L., & Lees, A. J. (1992). Accuracy of clinical diagnosis of idiopathic Parkinson's disease: a clinico-pathological study of 100 cases. *Journal of Neurology, Neurosurgery & Psychiatry, 55*(3), 181-184. doi:10.1136/jnnp.55.3.181

Hunnicutt-Ferguson, K., Hoxha, D., & Gollan, J. (2012). Exploring sudden gains in behavioral activation therapy for Major Depressive Disorder. *Behaviour Research and Therapy, 50*(3), 223-230. doi:10.1016/j.brat.2012.01.005

Iancu, I., Bodner, E., Roitman, S., Piccone Sapir, A., Poreh, A., & Kotler, M. (2010). Impulsivity, aggression and suicide risk among male schizophrenia patients. *Psychopathology, 43*(4), 223-229. doi:10.1159/000313520

Jankovic, J. (2008). Parkinson’s disease: clinical features and diagnosis. *Journal of Neurology, Neurosurgery & Psychiatry, 79*(4), 368. doi:10.1136/jnnp.2007.131045

Jankovic, J., & Aguilar, L. G. (2008). Current approaches to the treatment of Parkinson’s disease. *Neuropsychiatric Disease and Treatment, 4*(4), 743-757. doi:10.2147/ndt.s2006

Jasper, F., & Witthöft, M. (2011). Health anxiety and attentional bias: The time course of vigilance and avoidance in light of pictorial illness information. *Journal of Anxiety Disorders, 25*(8), 1131-1138. doi:10.1016/j.janxdis.2011.08.004

Jellinger, K. A. (2012). Neuropathology of sporadic Parkinson's disease: Evaluation and changes of concepts. In (Vol. 27, pp. 8-30). Hoboken.

Jellinger, K. A. (2013). Mild cognitive impairment in Parkinson disease: Heterogenous mechanisms. *Journal of Neural Transmission, 120*(1), 157-167. doi:10.1007/s00702-012-0771-5

Jellinger, K. A. (2015). Neuropathobiology of non-motor symptoms in Parkinson disease. *Translational Neuroscience, Neurology and Preclinical Neurological Studies, Psychiatry and Preclinical Psychiatric Studies, 122*(10), 1429-1440. doi:10.1007/s00702-015-1405-5

Jordan, L. L., Zahodne, L. B., Okun, M. S., & Bowers, D. (2013). Hedonic and behavioral deficits associated with apathy in Parkinson's disease: Potential treatment implications. *Movement Disorders, 28*(9), 1301-1304. doi:10.1002/mds.25496

Jorm, A. F., Christensen, H., Henderson, A. S., Jacomb, P. A., Korten, A. E., & Rodgers, B. (1998). Using the BIS/BAS scales to measure behavioural inhibition and behavioural activation: Factor structure, validity and norms in a large community sample. *Personality and Individual Differences, 26*(1), 49-58. doi:10.1016/S0191-8869(98)00143-3

Joshua, W. B., Michael, T. T., Ronald, L. C., Neil, D. W., Stephen, D. B., Rui, L., . . . David, H. Z. (2010). Mesolimbic dopamine reward system hypersensitivity in individuals with psychopathic traits. *Nature Neuroscience, 13*(4), 419. doi:10.1038/nn.2510

Kaladjian, A., Jeanningros, R., Azorin, J. M., Anton, J. L., & Mazzola-Pomietto, P. (2011). Impulsivity and neural correlates of response inhibition in schizophrenia. *Psychological Medicine, 41*(2), 291-299. doi:10.1017/S0033291710000796

Kalaitzakis, M. E., Graeber, M. B., Gentleman, S. M., & Pearce, R. K. B. (2008). The dorsal motor nucleus of the vagus is not an obligatory trigger site of Parkinson's disease: A critical analysis of α-synuclein staging. *Neuropathology and Applied Neurobiology, 34*(3), 284-295. doi:10.1111/j.1365-2990.2007.00923.x

Kalia, L. V., & Lang, A. E. (2015). Parkinson's disease. *The Lancet, 386*(9996), 896-912. doi:10.1016/S0140-6736(14)61393-3

Kanter, J. W., Puspitasari, A. J., Santos, M. M., & Nagy, G. A. (2012). Behavioural activation: history, evidence and promise. In (Vol. 200, pp. 361).

Kao, Y.-C., & Liu, Y.-P. (2010). The Beck Cognitive Insight Scale (BCIS): translation and validation of the Taiwanese version. *BMC Psychiatry, 10*(1), 27. doi:10.1186/1471-244X-10-27

Kaur, A., Butow, P., & Thewes, B. (2011). Do metacognitions predict attentional bias in health anxiety? *Cognitive Therapy and Research, 35*(6), 575-580. doi:10.1007/s10608-011-9387-6

Kawasaki, I., Baba, T., Takeda, A., & Mori, E. (2016). Loss of awareness of hyposmia is associated with mild cognitive impairment in Parkinson's disease. *Parkinsonism & Related Disorders, 22*, 74-79. doi:10.1016/j.parkreldis.2015.11.015

Kehagia, A. A., Barker, R. A., & Robbins, T. W. (2010). Neuropsychological and clinical heterogeneity of cognitive impairment and dementia in patients with Parkinson's disease. *The Lancet Neurology, 9*(12), 1200-1213. doi:10.1016/S1474-4422(10)70212-X

Kehagia, A. A., Barker, R. A., & Robbins, T. W. (2013). Cognitive impairment in Parkinson’s disease: The dual syndrome hypothesis. *Neurodegenerative Diseases, 11*(2), 79-92. doi:10.1159/000341998

Kehagia, A. A., Housden, C. R., Regenthal, R., Barker, R. A., Müller, U., Rowe, J., . . . Robbins, T. W. (2014). Targeting impulsivity in Parkinson's disease using atomoxetine. *Brain, 137*(Pt 7), 1986-1997. doi:10.1093/brain/awu117

Kester, H. M., Sevy, S., Yechiam, E., Burdick, K. E., Cervellione, K. L., & Kumra, S. (2006). Decision-making impairments in adolescents with early-onset schizophrenia. *Schizophrenia Research, 85*(1), 113-123. doi:10.1016/j.schres.2006.02.028

Kikyo, H., Ohki, K., & Miyashita, Y. (2002). Neural correlates for feeling-of-knowing: An fMRI Parametric Analysis. *Neuron, 36*(1), 177-186. doi:10.1016/S0896-6273(02)00939-X

King, K., Patock-Peckham, J., Dager, A., Thimm, K., & Gates, J. (2014). On the mismeasurement of impulsivity: Trait, behavioral, and neural models in alcohol research among adolescents and young adults. *Current Addiction Reports, 1*(1), 19-32. doi:10.1007/s40429-013-0005-4

Kingwell, K. (2017). Zeroing in on neurodegenerative α-synuclein. *Nature Reviews Drug Discovery, 16*, 371. doi:10.1038/nrd.2017.95

Kirisci, L., Tarter, R., Mezzich, A., & Vanyukov, M. (2007). Developmental trajectory classes in substance use disorder etiology. *Psychology of Addictive Behaviors, 21*(3), 287-296. doi:10.1037/0893-164X.21.3.287

Kish, S. J., Tong, J., Hornykiewicz, O., Rajput, A., Chang, L.-J., Guttman, M., & Furukawa, Y. (2008). Preferential loss of serotonin markers in caudate versus putamen in Parkinson's disease. *Brain, 131*(1), 120-131. doi:10.1093/brain/awm239

Klein, C., & Westenberger, A. (2012). Genetics of Parkinson's Disease. *Cold Spring Harbor Perspectives in Medicine, 2*(1), a008888. doi:10.1101/cshperspect.a008888

Kline, E., Hendel, V., Friedman-Yakoobian, M., Mesholam-Gately, R. I., Findeisen, A., Zimmet, S., . . . Seidman, L. J. (2018). A comparison of neurocognition and functioning in first episode psychosis populations: do research samples reflect the real world? *Social Psychiatry and Psychiatric Epidemiology*. doi:10.1007/s00127-018-1631-x

Klingelhoefer, L., & Reichmann, H. (2015). Pathogenesis of Parkinson disease-the gut-brain axis and environmental factors. In *Nat. Rev. Neurol.* (Vol. 11, pp. 625-636).

Klos, K. J., Bower, J. H., Josephs, K. A., Matsumoto, J. Y., & Ahlskog, J. E. (2005). Pathological hypersexuality predominantly linked to adjuvant dopamine agonist therapy in Parkinson's disease and multiple system atrophy. *Parkinsonism & Related Disorders, 11*(6), 381-386. doi:10.1016/j.parkreldis.2005.06.005

Knopman, D. S., Roberts, R. O., Geda, Y. E., Pankratz, V. S., Christianson, T. J. H., Petersen, R. C., & Rocca, W. A. (2010). Validation of the Telephone Interview for Cognitive Status-modified in subjects with normal cognition, mild cognitive impairment, or dementia. *Neuroepidemiology, 34*(1), 34-42. doi:10.1159/000255464

Kovács, I., Richman, M. J., Janka, Z., Maraz, A., & Andó, B. (2017). Decision making measured by the Iowa Gambling Task in alcohol use disorder and gambling disorder: a systematic review and meta-analysis. *Drug and Alcohol Dependence, 181*, 152-161. doi:10.1016/j.drugalcdep.2017.09.023

Kovács, N., Makkos, A., Aschermann, Z., Pal, E., Janszky, J., Karadi, K., & Komoly, S. (2015). High frequency repetitive transcranial magnetic stimulation can improve depression in Parkinson's disease. *Journal of the Neurological Sciences, 357*, e54. doi:10.1016/j.jns.2015.08.215

Kowal, S. L., Dall, T. M., Chakrabarti, R., Storm, M. V., & Jain, A. (2013). The current and projected economic burden of Parkinson's disease in the United States. *Movement Disorders, 28*(3), 311-318. doi:10.1002/mds.25292

Kua, Z. J., Pachana, N. A., Byrne, G. J., O'Sullivan, J. D., Marsh, R., Torbey, E., . . . Dissanayaka, N. N. W. (2018). How Well Do Caregivers Detect Depression and Anxiety in Patients With Parkinson Disease? *Journal of Geriatric Psychiatry and Neurology, 31*(5), 227-236. doi:10.1177/0891988718788641

Kudlicka, A., Clare, L., & Hindle, J. V. (2011). Executive functions in Parkinson's disease: Systematic review and meta-analysis. *Movement Disorders, 26*(13), 2305-2315. doi:10.1002/mds.23868

Kudlicka, A., Clare, L., & Hindle, J. V. (2013). Awareness of executive deficits in people with Parkinson's disease. *Journal of the International Neuropsychological Society, 19*(05), 559-570. doi:doi:10.1017/S1355617713000064

Kulisevsky, J., Pagonabarraga, J., Pascual-Sedano, B., García-Sánchez, C., Gironell, A., & Trapecio Group, S. (2008). Prevalence and correlates of neuropsychiatric symptoms in Parkinson's disease without dementia. *Movement Disorders, 23*(13), 1889-1896. doi:10.1002/mds.22246

Kurlan, R., Daragjati, C., Como, P. G., McDermott, M. P., Trinidad, K. S., Roddy, S., . . . Robertson, M. M. (1996). Non-obscene complex socially inappropriate behavior in Tourette's syndrome. *The Journal of Neuropsychiatry and Clinical Neurosciences, 8*(3), 311. doi:10.1176/jnp.8.3.311

Kurz, A., Kurz, C., Ellis, K., & Lautenschlager, N. T. (2014). What is frontotemporal dementia? *Maturitas, 79*(2), 216-219. doi:10.1016/j.maturitas.2014.07.001

Lane, D. S., Cherek, R. D., Rhoades, M. H., Pietras, J. C., & Tcheremissine, V. O. (2003). Relationships Among Laboratory and Psychometric Measures of Impulsivity: Implications in Substance Abuse and Dependence. *Addictive Disorders and Their Treatment, 2*(2), 33-40. doi:10.1097/00132576-200302020-00001

Lanni, K. E., Ross, J. M., Higginson, C. I., Dressler, E. M., Sigvardt, K. A., Zhang, L., . . . Disbrow, E. A. (2014). Perceived and performance-based executive dysfunction in Parkinson's disease. *Journal of Clinical and Experimental Neuropsychology, 36*(4), 342-355. doi:10.1080/13803395.2014.892059

Lansbergen, M. M., Schutter, D. J. L. G., & Kenemans, J. L. (2007). Subjective impulsivity and baseline EEG in relation to stopping performance. *Brain Research, 1148*, 161-169. doi:10.1016/j.brainres.2007.02.034

Larsen, K. R., Nevo, D., & Rich, E. (2008, 7-10 Jan. 2008). *Exploring the Semantic Validity of Questionnaire Scales.* Paper presented at the Proceedings of the 41st Annual Hawaii International Conference on System Sciences (HICSS 2008).

Lauriola, M., Panno, A., Levin, I. P., & Lejuez, C. W. (2014). Individual differences in risky decision making: A meta-analysis of sensation seeking and impulsivity with the balloon analogue risk task. *Journal of Behavioral Decision Making, 27*(1), 20-36. doi:10.1002/bdm.1784

Lawrence, B. J., Gasson, N., & Loftus, A. M. (2016). Prevalence and subtypes of mild cognitive impairment in Parkinson's disease. *Scientific Reports, 6*, 33929. doi:10.1038/srep33929

Lebouvier, T., Neunlist, M., Bruley des Varannes, S., Coron, E., Drouard, A., Guyen, J.-M., . . . Derkinderen, P. (2010). Colonic biopsies to assess the neuropathology of Parkinson's disease and its relationship with symptoms. *PLoS ONE, 5*(9), e12728. doi:10.1371/journal.pone.0012728

Lee, J., Chun, J., Lee, S.-H., Seung-Koo, L., & Jae-Jin, K. (2015). Altered neural basis of the reality processing and its relation to cognitive insight in schizophrenia. *PLoS ONE, 10*(3), e0120478. doi:10.1371/journal.pone.0120478

Leeman, R. F., Billingsley, B. E., & Potenza, M. N. (2012). Impulse control disorders in Parkinson's disease: background and update on prevention and management. *Neurodegenerative Disease Management, 2*(4), 389-400. doi:10.2217/nmt.12.35

Lehrner, J., Kogler, S., Lamm, C., Moser, D., Klug, S., Pusswald, G., . . . Auff, E. (2015). Awareness of memory deficits in subjective cognitive decline, mild cognitive impairment, Alzheimer's disease and Parkinson's disease. *International Psychogeriatrics, 27*(3), 357-366. doi:10.1017/S1041610214002245

Lejuez, C. W., Aklin, W., Daughters, S., Zvolensky, M., Kahler, C., & Gwadz, M. (2007). Reliability and validity of the youth version of the balloon analogue risk task (BART-Y) in the assessment of risk-taking behavior among inner-city adolescents. *Journal of Clinical Child and Adolescent Psychology, 36*(1), 106-111. doi:10.1207/s15374424jccp3601_11

Lejuez, C. W., Aklin, W. M., Jones, H. A., Richards, J. B., Strong, D. R., Kahler, C. W., & Read, J. P. (2003). The Balloon Analogue Risk Task (BART) differentiates smokers and nonsmokers. *Experimental and Clinical Psychopharmacology, 11*(1), 26-33. doi:10.1037/1064-1297.11.1.26

Lejuez, C. W., Aklin, W. M., Zvolensky, M. J., & Pedulla, C. M. (2003). Evaluation of the Balloon Analogue Risk Task (BART) as a predictor of adolescent real-world risk-taking behaviours. *Journal of Adolescence, 26*(4), 475-479. doi:10.1016/S0140-1971(03)00036-8

Lejuez, C. W., Read, J. P., Kahler, C. W., Richards, J., Ramsey, S., Stuart, G., . . . Brown, R. (2002). Evaluation of a behavioral measure of risk taking: The Balloon Analogue Risk Task (BART). *Journal of Experimental Psychology: Applied, 8*(2), 75-84. doi:10.1037//1076-898X.8.2.75

Leroi, I., Harbishettar, V., Andrews, M., McDonald, K., Byrne, E. J., & Burns, A. (2012). Carer burden in apathy and impulse control disorders in Parkinson's disease. *International Journal of Geriatric Psychiatry, 27*(2), 160-166. doi:10.1002/gps.2704

Lesieur, H. R., & Blume, S. B. (1987). The South Oaks Gambling Screen (SOGS): A new instrument for the identification of pathological gamblers. *American Journal of Psychiatry, 144*, 1184-1188. doi:10.1176/ajp.144.9.1184

Lewis, S. J. G., & Barker, R. A. (2009). Understanding the dopaminergic deficits in Parkinson's disease: Insights into disease heterogeneity. *Journal of Clinical Neuroscience, 16*(5), 620-625. doi:10.1016/j.jocn.2008.08.020

Lewis, S. J. G., Dove, A., Robbins, T. W., Barker, R. A., & Owen, A. M. (2003). Cognitive impairments in early Parkinson's disease are accompanied by reductions in activity in frontostriatal neural circuitry. *The Journal of Neuroscience, 23*(15), 6351. doi:10.1523/JNEUROSCI.23-15-06351.2003

Lim, S.-Y., Zuroswski, M., & Moro, E. (2010). Impulsive-compulsive behaviors and subthalamic nucleus deep brain stimulation in parkinson's disease: Review of the literature. *The European Neurological Journal, 2*(2), 1-10.

Lin, C. H., Lin, J. W., Liu, Y. C., Chang, C. H., & Wu, R. M. (2015). Risk of Parkinson's disease following anxiety disorders: a nationwide population-based cohort study. *European Journal of Neurology, 22*(9), 1280-1287. doi:10.1111/ene.12740

Lin, C. H., Song, T. J., Chen, Y. Y., Lee, W. K., & Chiu, Y. C. (2013). Reexamining the validity and reliability of the clinical version of the Iowa gambling task: Evidence from a normal subject group. *Frontiers in Psychology, 4*. doi:10.3389/fpsyg.2013.00220

Litvan, I., Goldman, J. G., Tröster, A. I., Schmand, B. A., Weintraub, D., Petersen, R. C., . . . Emre, M. (2012). Diagnostic criteria for mild cognitive impairment in Parkinson's disease: Movement Disorder Society Task Force guidelines. *Movement Disorders, 27*(3), 349-356. doi:10.1002/mds.24893

Liu, K. C. M., Chan, R. C. K., Chan, K. K. S., Tang, J. Y. M., Chiu, C. P. Y., Lam, M. M. L., . . . Chen, E. Y. H. (2011). Executive function in first-episode schizophrenia: A

three-year longitudinal study of an ecologically valid test. *Schizophrenia Research, 126*(1–3), 87-92. doi:10.1016/j.schres.2010.11.023

Louter, M., Aarden, W. C. C. A., Lion, J., Bloem, B. R., & Overeem, S. (2012). Recognition and diagnosis of sleep disorders in Parkinson's disease. *Journal of Neurology, 259*(10), 2031-2040. doi:10.1007/s00415-012-6505-7

Luman, M., Tripp, G., & Scheres, A. (2010). Identifying the neurobiology of altered reinforcement sensitivity in ADHD: A review and research agenda. *Neuroscience & Biobehavioral Reviews, 34*(5), 744-754. doi:10.1016/j.neubiorev.2009.11.021

Lysaker, P. H., Bryson, G. J., Lancaster, R. S., Evans, J. D., & Bell, M. D. (2003). Insight in schizophrenia: associations with executive function and coping style. *Schizophrenia Research, 59*(1), 41-47. doi:10.1016/S0920-9964(01)00383-8

Mack, J., Okai, D., Brown , R. G., Askey-Jones, S., Chaudhuri, K. R., Martin, A., . . . David, A. S. (2013). The role of self-awareness and cognitive dysfunction in Parkinson's disease with and without impulse-control disorder. *The Journal of Neuropsychiatry and Clinical Neurosciences, 25*(2), 141-149. doi:10.1176/appi.neuropsych.12030076

Macleod, A. D., Grieve, J. W. K., & Counsell, C. E. (2016). A systematic review of loss of independence in Parkinson's disease. *Journal of Neurology, 263*(1), 1-10. doi:10.1007/s00415-015-7847-8

Macphee, J. A. G., & Carson, J. A. A. (2013). Impulse control disorders in Parkinson disease: Is cognitive-behavioral therapy worth a wager? *Neurology, 80*(9), 782-783. doi:10.1212/WNL.0b013e31828407ef

MacPherson, L., Magidson, J. F., Reynolds, E. K., Kahler, C. W., & Lejuez, C. W. (2010). Changes in sensation seeking and risk-taking propensity predict increases in alcohol use among early adolescents. *Alcoholism: Clinical and Experimental Research, 34*(8), 1400-1408. doi:10.1111/j.1530-0277.2010.01223.x

Maier, F., & Prigatano, G. P. (2017). Impaired self-awareness of motor disturbances in Parkinson's disease. *Archives of Clinical Neuropsychology, 32*(7), 802-809. doi:10.1093/arclin/acx094

Maloney, E. M., Djamshidian, A., & O'Sullivan, S. S. (2017). Phenomenology and epidemiology of impulsive-compulsive behaviours in Parkinson's disease, atypical Parkinsonian disorders and non-Parkinsonian populations. *Journal of the Neurological Sciences, 374*, 47-52. doi:10.1016/j.jns.2016.12.058

Mandir, A. S., & Vaughan, C. (2000). Pathophysiology of Parkinson's disease. *International Review of Psychiatry, 12*(4), 270-280. doi:10.1080/09540260020002497

Manes, F. F., Torralva, T., Roca, M., Gleichgerrcht, E., Bekinschtein, T. A., & Hodges, J. R. (2010). Frontotemporal dementia presenting as pathological gambling. *Nature reviews. Neurology, 6*(6), 347. doi:10.1038/nrneurol.2010.34

Mania, I., Evcimen, H., & Mathews, M. (2006). Citalopram treatment for inappropriate sexual behavior in a cognitively impaired patient. *Primary care companion to the Journal of clinical psychiatry, 8*(2), 106-106. doi:10.4088/pcc.v08n0208b

Manza, P., Amandola, M., Tatineni, V., Li, C.-S. R., & Leung, H.-C. (2017). Response inhibition in Parkinson's disease: a meta-analysis of dopaminergic medication and disease duration effects. *NPJ Parkinson's disease, 3*, 23-23. doi:10.1038/s41531-017-0024-2

Maréchal, E., Denoiseux, B., Thys, E., Crosiers, D., Pickut, B., & Cras, P. (2015). Impulse control disorders in Parkinson's disease: An overview from neurobiology to treatment. *Journal of Neurology, 262*(1), 7-20. doi:10.1007/s00415-014-7361-4

Martin, J. M., Warman, D. M., & Lysaker, P. H. (2010). Cognitive insight in non-psychiatric individuals and individuals with psychosis: An examination using the Beck Cognitive Insight Scale. *Schizophrenia Research, 121*(1), 39-45. doi:10.1016/j.schres.2010.03.028

Martinez-Martin, P., Chaudhuri, K. R., Rojo-Abuin, J. M., Rodriguez-Blazquez, C., Alvarez-Sanchez, M., Arakaki, T., . . . Goetz, C. G. (2015). Assessing the non-motor symptoms of Parkinson's disease: MDS-UPDRS and NMS Scale. *European Journal of Neurology, 22*(1), 37-43. doi:10.1111/ene.12165

Martinez-Martin, P., & Forjaz, M. J. (2006). Metric attributes of the unified Parkinson's disease rating scale 3.0 battery: Part I, feasibility, scaling assumptions, reliability, and precision. *Movement Disorders, 21*(8), 1182-1188. doi:10.1002/mds.20916

Martinez-Martin, P., Leentjens, A. F. G., de Pedro-Cuesta, J., Chaudhuri, K. R., Schrag, A. E., & Weintraub, D. (2016). Accuracy of screening instruments for detection of neuropsychiatric syndromes in Parkinson's disease. *Movement Disorders, 31*(3), 270-279. doi:10.1002/mds.26522

Martinez-Martin, P., Rodriguez-Blazquez, C., & Catalan, M. J. (2018). Independent and Complementary Validation of the QUIP-RS in Advanced Parkinson's Disease. *Movement Disorders Clinical Practice, 5*(3), 341-342. doi:10.1002/mdc3.12603

Martinez-Martin, P., Rodriguez-Blazquez, C., & Catalan, M. J. (2018). Independent and complementary validation of the QUIP-RS in advanced Parkinson's Disease. *Movement Disorders Clinical Practice, 0*(0). doi:10.1002/mdc3.12603

Martinez-Martin, P., Rodriguez-Blazquez, C., Kurtis, M. M., & Chaudhuri, K. R. (2011). The impact of non-motor symptoms on health-related quality of life of patients with Parkinson's disease. *Movement Disorders, 26*(3), 399-406. doi:10.1002/mds.23462

Martini, A., Lago, D. D., Edelstyn, N. M. J., Grange, J. A., & Tamburin, S. (2018). Impulse control disorder in Parkinson's disease: A meta-analysis of cognitive, affective, and motivational correlates. *Frontiers in Neurology, 9*. doi:10.3389/fneur.2018.00654

Matochik, J. A., London, E. D., Eldreth, D. A., Cadet, J.-L., & Bolla, K. I. (2003). Frontal cortical tissue composition in abstinent cocaine abusers: a magnetic resonance imaging study. *NeuroImage, 19*(3), 1095-1102. doi:10.1016/S1053-8119(03)00244-1

Mattson, M. P. (2014). Interventions that improve body and brain bioenergetics for Parkinson's disease risk reduction and therapy. In *J. Parkinsons Dis.* (Vol. 4, pp. 1-13).

McKinlay, A., Grace, R. C., Dalrymple-Alford, J. C., Anderson, T. J., Fink, J., & Roger, D. (2008). Neuropsychiatric problems in Parkinson's disease: Comparisons between self and caregiver report. *Aging & Mental Health, 12*(5), 647-653. doi:10.1080/13607860802343225

McMillan, P. J., White, S. S., Franklin, A., Greenup, J. L., Leverenz, J. B., Raskind, M. A., & Szot, P. (2011). Differential response of the central noradrenergic nervous system to the loss of locus coeruleus neurons in Parkinson's disease and Alzheimer's disease. *Brain Research, 1373*, 240-252. doi:10.1016/j.brainres.2010.12.015

Meehl, P. (1956). Wanted - a good cookbook. *American Psychologist, 11*(6), 263-272. doi:10.1037/h0044164

Merola, A., Romagnolo, A., Rizzi, L., Rizzone, M. G., Zibetti, M., Lanotte, M., . . . Lopiano, L. (2017). Impulse control behaviors and subthalamic deep brain stimulation in Parkinson disease. *Journal of Neurology, 264*(1), 40. doi:10.1007/s00415-016-8314-x

Mestre, T. A., Strafella, A. P., Thomsen, T., Voon, V., & Miyasaki, J. (2013). Diagnosis and treatment of impulse control disorders in patients with movement disorders. *Therapeutic Advances in Neurological Disorders, 6*(3), 175-188. doi:10.1177/1756285613476127

Mier, D., Bailer, J., Ofer, J., Kerstner, T., Zamoscik, V., Rist, F., . . . Diener, C. (2017). Neural correlates of an attentional bias to health-threatening stimuli in individuals with pathological health anxiety. *Journal of psychiatry & neuroscience : JPN, 42*(3), 200-209. doi:10.1503/jpn.160081

Miller, J. W., Stromeyer, W. R., & Schwieterman, M. A. (2013). Extensions of the johnson-neyman technique to linear models with curvilinear effects: Derivations and analytical tools. *Multivariate Behavioral Research, 48*(2), 267-300. doi:10.1080/00273171.2013.763567

Minzenberg, M. J., Laird, A. R., Thelen, S., Carter, C. S., & Glahn, D. C. (2009). Meta-analysis of 41 functional neuroimaging studies of executive function in schizophrenia. *Archives of General Psychiatry, 66*(8), 811-822. doi:10.1001/archgenpsychiatry.2009.91

Mishra, S., Lalumière, M. L., & Williams, R. J. (2010). Gambling as a form of risk-taking: Individual differences in personality, risk-accepting attitudes, and behavioral preferences for risk. *Personality and Individual Differences, 49*(6), 616-621. doi:10.1016/j.paid.2010.05.032

Miwa, H. (2007). Stereotyped behavior or punding in Parkinson's disease. *Official Journal of the European Neurological Society, 254*(5), 61-67. doi:10.1007/s00415-007-5010-x

Moisan, F., Kab, S., Mohamed, F., Canonico, M., Le Guern, M., Quintin, C., . . . Elbaz, A. (2015). Parkinson disease male-to-female ratios increase with age: French nationwide study and meta-analysis. *Journal of Neurology, Neurosurgery & Psychiatry*. doi:10.1136/jnnp-2015-312283

Moon, H., Townsend, A. L., Dilworth-Anderson, P., & Whitlatch, C. J. (2016). Predictors of discrepancy between care recipients with mild-to-moderate dementia and their caregivers on perceptions of the care recipients' quality of life. *American Journal of Alzheimer's Disease & Other Dementias, 31*(6), 508-515. doi:10.1177/1533317516653819

Moos, R. H., Schutte, K. K., Brennan, P. L., & Moos, B. S. (2009). Older adults' alcohol consumption and late-life drinking problems: a 20-year perspective. *Addiction, 104*(8), 1293-1302. doi:10.1111/j.1360-0443.2009.02604.x

Mosley, P. E., Paliwal, S., Robinson, K., Coyne, T., Silburn, P., Tittgemeyer, M., . . . Perry, A. (2019). The structural connectivity of discrete networks underlies impulsivity and gambling in Parkinson's disease. *Brain, 142*(12), 3917-3935. doi:10.1093/brain/awz327

Moustafa, A. A., Chakravarthy, S., Phillips, J. R., Gupta, A., Keri, S., Polner, B., . . . Jahanshahi, M. (2016). Motor symptoms in Parkinson's disease: A unified framework. *Neuroscience & Biobehavioral Reviews, 68*, 727-740. doi:10.1016/j.neubiorev.2016.07.010

Mueller, C., Rajkumar, A. P., Wan, Y. M., Velayudhan, L., ffytche, D., Chaudhuri, K. R., & Aarsland, D. (2018). Assessment and management of neuropsychiatric symptoms in Parkinson's disease. *CNS Drugs, 32*(7), 621-635. doi:10.1007/s40263-018-0540-6

Müller, M. L. T. M., & Bohnen, N. I. (2013). Cholinergic dysfunction in Parkinson's disease. *Current Neurology and Neuroscience Reports, 13*(9), 377. doi:10.1007/s11910-013-0377-9

Mullin, S., & Schapira, A. (2015). The genetics of Parkinson's disease. *British Medical Bulletin, 114*(1), 39-52. doi:10.1093/bmb/ldv022

Mursaleen, L. R., & Stamford, J. A. (2016). Drugs of abuse and Parkinson's disease. *Progress in Neuro-Psychopharmacology and Biological Psychiatry, 64*, 209-217. doi:10.1016/j.pnpbp.2015.03.013

Naismith, S. L., Pereira, M., Shine, J., M., & Lewis, S. J. G. (2010). How well do caregivers detect mild cognitive change in Parkinson's disease? *Movement Disorders, 26*(1), 161-164. doi:10.1002/mds.23331

Nanda, P., Tandon, N., Mathew, I. T., Padmanabhan, J. L., Clementz, B. A., Pearlson, G. D., . . . Keshavan, M. S. (2016). Impulsivity across the psychosis spectrum: Correlates of cortical volume, suicidal history, and social and global function. *Schizophrenia Research, 170*(1), 80-86. doi:10.1016/j.schres.2015.11.030

Nejtek, V. A., Kaiser, K. A., Zhang, B., & Djokovic, M. (2013). Iowa Gambling Task scores predict future drug use in bipolar disorder outpatients with stimulant dependence. *Psychiatry Research, 210*(3), 871-879. doi:10.1016/j.psychres.2013.08.021

Nelson, A. B., & Kreitzer, A. C. (2014). Reassessing models of basal ganglia function and dysfunction. *Annu. Rev. Neurosci., 37*, 117-135. doi:10.1146/annurev-neuro-071013-013916

Nigg, J. T. (2013). Attention-deficit/hyperactivity disorder and adverse health outcomes. *Clinical Psychology Review, 33*(2), 215-228. doi:10.1016/j.cpr.2012.11.005

Nimon, K., Shuck, B., & Zigarmi, D. (2016). Construct overlap between employee engagement and job satisfaction: A function of semantic equivalence? *Journal of Happiness Studies, 17*(3), 1149-1171. doi:10.1007/s10902-015-9636-6

Nirenberg, M. J., & Waters, C. (2006). Compulsive eating and weight gain related to dopamine agonist use. *Movement Disorders, 21*(4), 524-529. doi:10.1002/mds.20757

Nonnekes, J., Timmer, M. H. M., de Vries, N. M., Rascol, O., Helmich, R. C., & Bloem, B. R. (2016). Unmasking levodopa resistance in Parkinson's disease. *Movement Disorders, 31*(11), 1602-1609. doi:10.1002/mds.26712

O'Callaghan, C., Naismith, S. L., Hodges, J. R., Lewis, S. J. G., & Hornberger, M. (2013). Fronto-striatal atrophy correlates of inhibitory dysfunction in Parkinson's disease versus behavioural variant frontotemporal dementia. *Cortex, 49*(7), 1833-1843. doi:10.1016/j.cortex.2012.12.003

O'Sullivan, S. S., Evans, A. H., Quinn, N. P., Lawrence, A. D., & Lees, A. J. (2010). Reckless generosity in Parkinson's disease. *Movement Disorders, 25*(2), 221-223. doi:10.1002/mds.22687

O'Sullivan, S. S., Wu, K., Politis, M., Lawrence, A. D., Evans, A. H., Bose, S. K., . . . Piccini, P. (2011). Cue-induced striatal dopamine release in Parkinson's disease-associated impulsive-compulsive behaviours. *Brain, 134*(4), 969-978. doi:10.1093/brain/awr003

O'Shea, E., Hopper, L., Marques, M., Gonçalves-Pereira, M., Woods, B., Jelley, H., . . . Irving, K. (2018). A comparison of self and proxy quality of life ratings for people

with dementia and their carers: a European prospective cohort study. *Aging & Mental Health*, 1-9. doi:10.1080/13607863.2018.1517727

Okai, D., Askey-Jones, S., Samuel, M., O'Sullivan, S. S., Chaudhuri, K. R., Martin, A., . . . David, A. S. (2013). Trial of CBT for impulse control behaviors affecting Parkinson patients and their caregivers. *Neurology, 80*(9), 792-799. doi:10.1212/WNL.0b013e3182840678

Okai, D., Askey-Jones, S., Mack, J., Martin, A., Chaudhuri, K. R., Samuel, M., . . . Brown, R. G. (2016). Parkinson's impulse-control scale for the severity rating of impulse-control behaviors in Parkinson's disease: A semistructured clinical assessment tool. *Movement Disorders Clinical Practice, 3*(5), 494-499. doi:10.1002/mdc3.12316

Olesen, J., Gustavsson, A., Svensson, M., Wittchen, H. U., Jönsson, B., on behalf of the, C. s. g., & the European Brain, C. (2012). The economic cost of brain disorders in Europe. *European Journal of Neurology, 19*(1), 155-162. doi:10.1111/j.1468-1331.2011.03590.x

Ouzir, M. (2013). Impulsivity in schizophrenia: A comprehensive update. *Aggression and Violent Behavior, 18*(2), 247-254. doi:10.1016/j.avb.2012.11.014

Pal, E., Nagy, F., Aschermann, Z., Balazs, E., & Kovacs, N. (2010). The impact of left prefrontal repetitive transcranial magnetic stimulation on depression in Parkinson's disease: A randomized, double-blind, placebo-controlled study. *Movement Disorders, 25*(14), 2311-2317. doi:10.1002/mds.23270

Paliwal, S., Mosley, P. E., Breakspear, M., Coyne, T., Silburn, P., Aponte, E., . . . Stephan, K. E. (2019). Subjective estimates of uncertainty during gambling and impulsivity after subthalamic deep brain stimulation for Parkinson's disease. *Scientific Reports, 9*(1), 14795. doi:10.1038/s41598-019-51164-2

Paliwal, S., Petzschner, F. H., Schmitz, A. K., Tittgemeyer, M., & Stephan, K. E. (2014). A model-based analysis of impulsivity using a slot-machine gambling paradigm. *Frontiers in Human Neuroscience, 8*(428). doi:10.3389/fnhum.2014.00428

Pan, T., Kondo, S., Le, W., & Jankovic, J. (2008). The role of autophagy-lysosome pathway in neurodegeneration associated with Parkinson's disease. *Brain, 131*(8), 1969-1978. doi:10.1093/brain/awm318

Papay, K., Mamikonyan, E., Siderowf, A. D., Duda, J. E., Lyons, K. E., Pahwa, R., . . . Weintraub, D. (2011). Patient versus informant reporting of ICD symptoms in Parkinson's disease using the QUIP: Validity and variability. *Parkinsonism & Related Disorders, 17*(3), 153-155. doi:10.1016/j.parkreldis

Patton, J. H., Stanford, M. S., & Barratt, E. S. (1995). Factor structure of the Barratt impulsiveness scale. *Journal of Clinical Psychology, 51*(6), 768-774. doi:10.1002/1097-4679(199511)51:6<768::AID-JCLP2270510607>3.0.CO;2-1

Pavese, N., Rivero-Bosch, M., Lewis, S. J., Whone, A. L., & Brooks, D. J. (2011). Progression of monoaminergic dysfunction in Parkinson's disease: A longitudinal 18F-dopa PET study. *NeuroImage, 56*(3), 1463-1468. doi:10.1016/j.neuroimage.2011.03.012

Penadés, R., Catalán, R., Rubia, K., Andrés, S., Salamero, M., & Gastó, C. (2007). Impaired response inhibition in obsessive compulsive disorder. *European Psychiatry, 22*(6), 404-410. doi:10.1016/j.eurpsy.2006.05.001

Penney, D., Sauvé, G., Joober, R., Malla, A. K., & Lepage, M. (2018). Establishing clinical cutoff values for the Beck Cognitive Insight Scale. *Cognitive Therapy and Research*. doi:10.1007/s10608-018-9963-0

Perez-Lloret, S., Rey, M. V., Fabre, N., Ory, F., Spampinato, U., Montastruc, J.-L., & Rascol, O. (2012). Do Parkinson's disease patients disclose their adverse events spontaneously? *European Journal of Clinical Pharmacology, 68*(5), 857-865. doi:10.1007/s00228-011-1198-x

Perry, E. K., Curtis, M., Dick, D. J., Candy, J. M., Atack, J. R., Bloxham, C. A., . . . Perry, R. H. (1985). Cholinergic correlates of cognitive impairment in Parkinson's disease: comparisons with Alzheimer's disease. *Journal of Neurology, Neurosurgery and Psychiatry, 48*(5), 413. doi:10.1136/jnnp.48.5.413

Peters, F., Perani, D., Herholz, K., Holthoff, V., Beuthien-Baumann, B., Sorbi, S., . . . Salmon, E. (2006). Orbitofrontal dysfunction related to both apathy and disinhibition in frontotemporal dementia. *Dementia and Geriatric Cognitive Disorders, 21*(5-6), 373-379. doi:10.1159/000091898

Phu, A. L., Xu, Z., Brakoulias, V., Mahant, N., Fung, V. S. C., Moore, G. D., . . . Krause, M. (2014). Effect of impulse control disorders on disability and quality of life in Parkinson's disease patients. *Journal of Clinical Neuroscience, 21*(1), 63-66. doi:10.1016/j.jocn.2013.02.032

Picillo, M., Nicoletti, A., Fetoni, V., Garavaglia, B., Barone, P., & Pellecchia, M. T. (2017). The relevance of gender in Parkinson's disease: a review. *Journal of Neurology, 264*(8), 1583-1607. doi:10.1007/s00415-016-8384-9

Pierce, R. C., & Kumaresan, V. (2006). The mesolimbic dopamine system: The final common pathway for the reinforcing effect of drugs of abuse? *Neuroscience & Biobehavioral Reviews, 30*(2), 215-238. doi:10.1016/j.neubiorev.2005.04.016

Pifl, C., Kish, S. J., & Hornykiewicz, O. (2012). Thalamic noradrenaline in Parkinson's disease: Deficits suggest role in motor and non-motor symptoms. *Movement Disorders, 27*(13), 1618-1624. doi:10.1002/mds.25109

Pineau, F., Roze, E., Lacomblez, L., Bonnet, A.-M., Vidailhet, M., Czernecki, V., & Corvol, J.-C. (2016). Executive functioning and risk-taking behavior in Parkinson's disease

patients with impulse control disorders. *Journal of Neural Transmission, 123*(6), 573-581. doi:10.1007/s00702-016-1549-y

Pizzagalli, D. A., Evins, A. E., Schetter, E. C., Frank, M. J., Pajtas, P. E., Santesso, D. L., & Culhane, M. (2008). Single dose of a dopamine agonist impairs reinforcement learning in humans: Behavioral evidence from a laboratory-based measure of reward responsiveness. *Psychopharmacology, 196*(2), 221-232. doi:10.1007/s00213-007-0957-y

Pizzagalli, D. A., Goetz, E., Ostacher, M., Iosifescu, D. V., & Perlis, R. H. (2008). Euthymic patients with bipolar disorder show decreased reward learning in a probabilistic reward task. *Biological Psychiatry, 64*(2), 162-168. doi:10.1016/j.biopsych.2007.12.001

Pizzagalli, D. A., Jahn, A. L., & O'Shea, J. P. (2005). Toward an objective characterization of an anhedonic phenotype: A signal-detection approach. *Biological Psychiatry, 57*(4), 319-327. doi:10.1016/j.biopsych.2004.11.026

Plessow, F., Fischer, R., Volkmann, J., & Schubert, T. (2014). Subthalamic deep brain stimulation restores automatic response activation and increases susceptibility to impulsive behavior in patients with Parkinson's disease. *Brain and Cognition, 87*, 16-21. doi:10.1016/j.bandc.2014.02.009

Poletti, M., Enrici, I., Bonuccelli, U., & Adenzato, M. (2011). Theory of mind in Parkinson's disease. *Behavioural Brain Research, 219*(2), 342-350. doi:10.1016/j.bbr.2011.01.010

Politis, M., Loane, C., Wu, K., O'Sullivan, S. S., Woodhead, Z., Kiferle, L., . . . Piccini, P. (2013). Neural response to visual sexual cues in dopamine treatment-linked hypersexuality in Parkinson's disease. *Brain, 136*(2), 400-411. doi:10.1093/brain/aws326

Politis, M., & Niccolini, F. (2015). Serotonin in Parkinson's disease. *Behavioural Brain Research, 277*(Supplement C), 136-145. doi:10.1016/j.bbr.2014.07.037

Politis, M., Wu, K., Loane, C., Kiferle, L., Molloy, S., Brooks, D. J., & Piccini, P. (2010). Staging of serotonergic dysfunction in Parkinson's disease: An in vivo 11C-DASB PET study. *Neurobiology of Disease, 40*(1), 216-221. doi:10.1016/j.nbd.2010.05.028

Pontone, G. M. (2017). Anxiety in Parkinson's: a complex syndrome of non-dopaminergic and dopaminergic etiology. *European Journal of Neurology, 24*(4), 541-542. doi:10.1111/ene.13242

Postuma, R. B., Berg, D., Stern, M., Poewe, W., Olanow, C. W., Oertel, W., . . . Deuschl, G. (2015). MDS clinical diagnostic criteria for Parkinson's disease. *Movement Disorders, 30*(12), 1591-1601. doi:10.1002/mds.26424

Poythress, N. G., Skeem, J. L., Weir, J., Lilienfeld, S. O., Douglas, K. S., Edens, J. F., & Kennealy, P. J. (2008). Psychometric properties of Carver and White's (1994) BIS/BAS scales in a large sample of offenders. *Personality and Individual Differences, 45*(8), 732-737. doi:10.1016/j.paid.2008.07.021

Prakash, K. M., Nadkarni, N. V., Lye, W. K., Yong, M. H., & Tan, E. K. (2016). The impact of non-motor symptoms on the quality of life of Parkinson's disease patients: a longitudinal study. *European Journal of Neurology, 23*(5), 854-860. doi:10.1111/ene.12950

Prediger, R. D. S., Matheus, F. C., Schwarzbold, M. L., Lima, M. M. S., & Vital, M. A. B. F. (2012). Anxiety in Parkinson's disease: A critical review of experimental and clinical studies. *Neuropharmacology, 62*(1), 115-124. doi:10.1016/j.neuropharm.2011.08.039

Pressman, P. S., & Miller, B. L. (2014). Diagnosis and management of behavioral variant frontotemporal dementia. *Biological Psychiatry, 75*(7), 574-581. doi:10.1016/j.biopsych.2013.11.006

Price, M., Lee, M., & Higgs, S. (2013). Impulsivity, eating behaviour and performance on a delay discounting task. *Appetite, 71*, 483. doi:10.1016/j.appet.2013.06.053

Pringsheim, T., Jette, N., Frolkis, A., & Steeves, T. D. L. (2014). The prevalence of Parkinson's disease: A systematic review and meta-analysis. *Movement Disorders, 29*(13), 1583-1590. doi:10.1002/mds.25945

Probst, C., Winter, L., Möller, B., Weber, H., Weintraub, D., Witt, K., . . . Eimeren, T. (2014). Validation of the questionnaire for impulsive-compulsive disorders in Parkinson's disease (QUIP) and the QUIP-rating scale in a German speaking sample. *Official Journal of the European Neurological Society, 261*(5), 936-942. doi:10.1007/s00415-014-7299-6

Pu, S., Nakagome, K., Yamada, T., Itakura, M., Satake, T., Ishida, H., . . . Kaneko, K. (2013). Association between cognitive insight and prefrontal function during a cognitive task in schizophrenia: A multichannel near-infrared spectroscopy study. *Schizophrenia Research, 150*(1), 81-87. doi:10.1016/j.schres.2013.07.048

Qamhawi, Z., Towey, D., Shah, B., Pagano, G., Seibyl, J., Marek, K., . . . Pavese, N. (2015). Clinical correlates of raphe serotonergic dysfunction in early Parkinson's disease. *Brain, 138*(10), 2964-2973. doi:10.1093/brain/awv215

Quik, M., O'Neill, M., & Perez, X. A. (2007). Nicotine neuroprotection against nigrostriatal damage: importance of the animal model. *Trends in Pharmacological Sciences, 28*(5), 229-235. doi:10.1016/j.tips.2007.03.001

Radakovic, R., Davenport, R., Starr John, M., & Abrahams, S. (2017). Apathy dimensions in Parkinson's disease. *International Journal of Geriatric Psychiatry, 33*(1), 151-158. doi:10.1002/gps.4697

Ramaekers, J. G., van Wel, J. H., Spronk, D., Franke, B., Kenis, G., Toennes, S. W., . . . Verkes, R. J. (2016). Cannabis and cocaine decrease cognitive impulse control and functional corticostriatal connectivity in drug users with low activity DBH genotypes. *Brain Imaging and Behavior, 10*(4), 1254-1263. doi:10.1007/s11682-015-9488-z

Ramaker, C., Marinus, J., Stiggelbout, A. M., & van Hilten, B. J. (2002). Systematic evaluation of rating scales for impairment and disability in Parkinson's disease. *Movement Disorders, 17*(5), 867-876. doi:10.1002/mds.10248

Ramirez-Zamora, A., Gee, L., Boyd, J., & Biller, J. (2016). Treatment of impulse control disorders in Parkinson's disease: Practical considerations and future directions. *Expert Review of Neurotherapeutics, 16*(4), 389-399. doi:10.1586/14737175.2016.1158103

Rana, A. Q., Saleh, M., Yousuf, M. S., Mansoor, W., Hussaini, S., Rahman, M., & Iqbal, Z. (2016). DOPA-sparing strategy in the treatment of young onset Parkinson's disease. *Journal of neurosciences in rural practice, 7*(1), 67-69. doi:10.4103/0976-3147.172155

Rao, H., Mamikonyan, E., Detre, J. A., Siderowf, A. D., Stern, M. B., Potenza, M. N., & Weintraub, D. (2010). Decreased ventral striatal activity with impulse control disorders in Parkinson's disease. *Movement Disorders, 25*(11), 1660-1669. doi:10.1002/mds.23147

Ready, R. E., & Clark, L. A. (2005). Psychiatric patient and informant reports of patient behavior. *Journal of Personality, 73*(1), 1-22. doi:10.1111/j.1467-6494.2004.00302.x

Reijnders, J. S. A. M., Ehrt, U., Weber, W. E. J., Aarsland, D., & Leentjens, A. F. G. (2008). A systematic review of prevalence studies of depression in Parkinson's disease. *Movement Disorders, 23*(2), 183-189. doi:10.1002/mds.21803

Reise, S. P., Moore, T. M., Sabb, F. W., Brown, A. K., & London, E. D. (2013). The Barratt Impulsiveness Scale–11: Reassessment of its structure in a community sample. *Psychological Assessment, 25*(2), 631-642. doi:10.1037/a0032161

Remy, P., Doder, M., Lees, A., Turjanski, N., & Brooks, D. (2005). Depression in Parkinson's disease: loss of dopamine and noradrenaline innervation in the limbic system. *Brain, 128*(6), 1314-1322. doi:10.1093/brain/awh445

Ricciardi, L., Demartini, B., Pomponi, M., Ricciardi, D., Morabito, B., Renna, R., . . . Bentivoglio, A. (2016). Impulsive compulsive behaviours in Parkinson's disease:

patients' versus caregivers' perceptions. *Official Journal of the European Neurological Society, 263*(5), 1019-1021. doi:10.1007/s00415-016-8079-2

Richter, A., Petrovic, A., Diekhof, E. K., Trost, S., Wolter, S., & Gruber, O. (2015). Hyperresponsivity and impaired prefrontal control of the mesolimbic reward system in schizophrenia. *Journal of Psychiatric Research, 71*, 8-15. doi:10.1016/j.jpsychires.2015.09.005

Rietdijk, C. D., Perez-Pardo, P., Garssen, J., van Wezel, R. J. A., & Kraneveld, A. D. (2017). Exploring Braak's Hypothesis of Parkinson's Disease. *Frontiers in Neurology, 8*(37). doi:10.3389/fneur.2017.00037

Rizzo, G., Copetti, M., Arcuti, S., Martino, D., Fontana, A., & Logroscino, G. (2016). Accuracy of clinical diagnosis of Parkinson disease: A systematic review and meta-analysis. *Neurology, 86*(6), 566-576. doi:10.1212/wnl.0000000000002350

Rochester, L., Yarnall, A. J., Baker, M. R., David, R. V., Lord, S., Galna, B., & Burn, D. J. (2012). Cholinergic dysfunction contributes to gait disturbance in early Parkinson's disease. *Brain, 135*(9), 2779-2788. doi:10.1093/brain/aws207

Romana, F. P., Colosimo, C., Vanacore, N., Di Rezze, S., Chianese, M., Fabbrini, G., & Meco, G. (2004). Prevalence and clinical features of hedonistic homeostatic dysregulation in Parkinson's disease. *Movement Disorders, 20*(1), 77-81. doi:10.1002/mds.20288

Rommelfanger, K. S., & Weinshenker, D. (2007). Norepinephrine: The redheaded stepchild of Parkinson's disease. *Biochemical Pharmacology, 74*(2), 177-190. doi:10.1016/j.bcp.2007.01.036

Ros, R., & Graziano, P. A. (2017). Social functioning in children with or at risk for Attention Deficit/Hyperactivity Disorder: A meta-analytic review. *Journal of Clinical Child & Adolescent Psychology*, 1-23. doi:10.1080/15374416.2016.1266644

Rosen, H. J. (2011). Anosognosia in neurodegenerative disease. *Neurocase, 17*(3), 231-241. doi:10.1080/13554794.2010.522588

Ross, G. W., Petrovitch, H., Abbott, R. D., Tanner, C. M., Popper, J., Masaki, K., . . . White, L. R. (2008). Association of olfactory dysfunction with risk for future Parkinson's disease. *Annals of Neurology, 63*(2), 167-173. doi:10.1002/ana.21291

Rushton, J. P., Brainerd, C. J., & Pressley, M. (1983). Behavioral development and construct validity: The principle of aggregation. *Psychological Bulletin, 94*(1), 18-38. doi:10.1037/0033-2909.94.1.18

Russo, G. B., Tirrell, E., Busch, A., & Carpenter, L. L. (2018). Behavioral activation therapy during transcranial magnetic stimulation for major depressive disorder. *Journal of Affective Disorders, 236*, 101-104. doi:10.1016/j.jad.2018.04.108

Samuel, M., Rodriguez-Oroz, M., Antonini, A., Brotchie, J. M., Ray Chaudhuri, K., Brown, R. G., . . . Lang, A. E. (2015). Management of impulse control disorders in Parkinson's disease: Controversies and future approaches. *Movement Disorders, 30*(2), 150-159. doi:10.1002/mds.26099

Santangelo, G., Barone, P., Trojano, L., & Vitale, C. (2013). Pathological gambling in Parkinson's disease. A comprehensive review. *Parkinsonism & Related Disorders, 19*(7), 645-653. doi:10.1016/j.parkreldis.2013.02.007

Santangelo, G., Raimo, S., & Barone, P. (2017). The relationship between Impulse Control Disorders and cognitive dysfunctions in Parkinson's Disease: A meta-analysis. *Neuroscience & Biobehavioral Reviews, 77*, 129-147. doi:10.1016/j.neubiorev.2017.02.018

Santangelo, G., Vitale, C., Trojano, L., Verde, F., Grossi, D., & Barone, P. (2009). Cognitive dysfunctions and pathological gambling in patients with Parkinson's disease. *Movement Disorders, 24*(6), 899-905. doi:10.1002/mds.22472

Schapira, A. H. V., Emre, M., Jenner, P., & Poewe, W. (2009). Levodopa in the treatment of Parkinson's disease. *European Journal of Neurology, 16*(9), 982-989. doi:10.1111/j.1468-1331.2009.02697.x

Schapira, A. H. V., & Tan, E. K. (2012). Optimizing treatment for Parkinson's disease. *European Journal of Neurology, 19*(12), 1483-1486. doi:10.1111/ene.12025

Schermelleh-Engel, K., Moosbrugger, H., & Müller, H. (2003). *Evaluating the Fit of Structural Equation Models: Tests of Significance and Descriptive Goodness-of-Fit Measures* (Vol. 8).

Schiehser, D., Liu, L., Lessig, S., Song, D., Obtera, K., Burke, M., . . . Vincent Filoteo, J. (2013). Predictors of discrepancies in parkinson's disease patient and caregiver ratings of apathy, disinhibition, and executive dysfunction before and after diagnosis. *International Neuropsychological Society. Journal, 19*(3), 295-304. doi:10.1017/S1355617712001385

Schmitt, T. A. (2011). Current methodological considerations in exploratory and confirmatory factor analysis. *Journal of Psychoeducational Assessment, 29*(4), 304-321. doi:10.1177/0734282911406653

Schnyer, D. M., Verfaellie, M., Alexander, M. P., LaFleche, G., Nicholls, L., & Kaszniak, A. W. (2004). A role for right medial prefrontal cortex in accurate feeling-of-knowing judgments: Evidence from patients with lesions to frontal cortex. *Neuropsychologia, 42*(7), 957-966. doi:10.1016/j.neuropsychologia.2003.11.020

Schultz, W. (2007). Behavioral dopamine signals. *Trends in Neurosciences, 30*(5), 203-210. doi:10.1016/j.tins.2007.03.007

Sedikides, C., & Gregg, A. P. (2008). Self-enhancement: Food for thought. *Perspectives on Psychological Science, 3*(2), 102-116. doi:10.1111/j.1745-6916.2008.00068.x

Sensi, M., Eleopra, R., Cavallo, M. A., Sette, E., Milani, P., Quatrale, R., . . . Data, P. G. (2004). Explosive-aggressive behavior related to bilateral subthalamic stimulation. *Parkinsonism & Related Disorders, 10*(4), 247-251. doi:10.1016/j.parkreldis.2004.01.007

Seppi, K., Weintraub, D., Coelho, M., Perez-Lloret, S., Fox, S. H., Katzenschlager, R., . . . Sampaio, C. (2011). The movement disorder society evidence-based medicine review update: Treatments for the non-motor symptoms of parkinson's disease. *Movement Disorders, 26*(S3), S42-S80. doi:10.1002/mds.23884

Sharma, L., Kohl, K., Morgan, T. A., & Clark, L. A. (2013). "Impulsivity": Relations between self-report and behavior. *Journal of Personality and Social Psychology, 104*(3), 559-575. doi:10.1037/a0031181

Sharma, L., Markon, K. E., & Clark, L. A. (2014). Toward a theory of distinct types of "impulsive" behaviors: A meta-analysis of self-report and behavioral measures. *Psychological Bulletin, 140*(2), 374-408. doi:10.1037/a0034418

Shimada, H., Hirano, S., Shinotoh, H., Aotsuka, A., Sato, K., Tanaka, N., . . . Irie, T. (2009). Mapping of brain acetylcholinesterase alterations in Lewy body disease by PET. *Neurology, 73*(4), 273-278. doi:10.1212/WNL.0b013e3181ab2b58

Shirley, M. C., & Sirocco, K. Y. (2014). Introduction to special section: ADHD, impulsivity, and alcohol abuse. *Experimental and Clinical Psychopharmacology, 22*(2), 97-99. doi:10.1037/a0036124

Silbert, L. C., & Kaye, J. (2010). Neuroimaging and cognition in Parkinson's disease dementia. *Brain Pathology, 20*(3), 646-653. doi:10.1111/j.1750-3639.2009.00368.x

Simioni, A. C., Dagher, A., & Fellows, L. K. (2012). Dissecting the effects of disease and treatment on impulsivity in Parkinson's disease. *Journal of the International Neuropsychological Society, 18*(6), 942-951. doi:10.1017/S135561771200094X

Smith, G. T., Fischer, S., Cyders, M. A., Annus, A. M., Spillane, N. S., & McCarthy, D. M. (2007). On the validity and utility of discriminating among impulsivity-like traits. *Assessment, 14*(2), 155-170. doi:10.1177/1073191106295527

Smith, K. M., & Dahodwala, N. (2014). Sex differences in Parkinson's disease and other movement disorders. *Experimental Neurology, 259*, 44-56. doi:10.1016/j.expneurol.2014.03.010

Squeglia, L. M., Boissoneault, J., Van Skike, C. E., Nixon, S. J., & Matthews, D. B. (2014). Age-related effects of alcohol from adolescent, adult, and aged populations using human and animal models. *Alcoholism: Clinical and Experimental Research, 38*(10), 2509-2516. doi:doi:10.1111/acer.12531

Sriram, A., Ward, H., Hassan, A., Iyer, S., Foote, K., Rodriguez, R., . . . Okun, M. (2013). Valproate as a treatment for dopamine dysregulation syndrome (DDS) in Parkinson's disease. *Official Journal of the European Neurological Society, 260*(2), 521-527. doi:10.1007/s00415-012-6669-1

Stanford, M. S., Mathias, C. W., Dougherty, D. M., Lake, S. L., Anderson, N. E., & Patton, J. H. (2009). Fifty years of the Barratt Impulsiveness Scale: An update and review. *Personality and Individual Differences, 47*(5), 385-395. doi:10.1016/j.paid.2009.04.008

Stautz, K., & Cooper, A. (2013). Impulsivity-related personality traits and adolescent alcohol use: A meta-analytic review. *Clinical Psychology Review, 33*(4), 574-592. doi:10.1016/j.cpr.2013.03.003

Stowe, R., Ives, N., Clarke, C. E., Handley, K., Furmston, A., Deane, K., . . . Gray, R. (2011). Meta-analysis of the comparative efficacy and safety of adjuvant treatment to levodopa in later Parkinson's disease. *Movement Disorders, 26*(4), 587-598. doi:10.1002/mds.23517

Suhr, J. A., & Tsanadis, J. (2007). Affect and personality correlates of the Iowa Gambling Task. *Personality and Individual Differences, 43*(1), 27-36. doi:10.1016/j.paid.2006.11.004

Suzanne, N. H., & Brian, K. (2009). The reward circuit: Linking primate anatomy and human imaging. *Neuropsychopharmacology, 35*(1), 4. doi:10.1038/npp.2009.129

Sveinbjornsdottir, S. (2016). The clinical symptoms of Parkinson's disease. *Journal of Neurochemistry, 139*, 318-324. doi:10.1111/jnc.13691

Tabbal, S. D., Ushe, M., Mink, J. W., Revilla, F. J., Wernle, A. R., Hong, M., . . . Perlmutter, J. S. (2008). Unilateral subthalamic nucleus stimulation has a measurable ipsilateral effect on rigidity and bradykinesia in parkinson disease. *Experimental Neurology, 211*(1), 234-242. doi:10.1016/j.expneurol.2008.01.024

Tagliavini, F., Pilleri, G., Bouras, C., & Constantinidis, J. (1984). The basal nucleus of Meynert in idiopathic Parkinson's disease. *Acta Neurologica Scandinavica, 70*(1), 20-28. doi:10.1111/j.1600-0404.1984.tb00798.x

Tan, S. K. H., Hartung, H., Sharp, T., & Temel, Y. (2011). Serotonin-dependent depression in Parkinson's disease: A role for the subthalamic nucleus? *Neuropharmacology, 61*(3), 387-399. doi:10.1016/j.neuropharm.2011.01.006

Tanner, C. M., & Comella, C. L. (2015). When brawn benefits brain: physical activity and Parkinson's disease risk. *Brain, 138*(2), 238-239. doi:10.1093/brain/awu351

Thanvi, B., & Lo, T. (2004). Long term motor complications of levodopa: clinical features, mechanisms, and management strategies. *Postgraduate Medical Journal, 80*(946), 452. doi:10.1136/pgmj.2003.013912

Thenganatt, M., & Jankovic, J. (2014). Parkinson disease subtypes. *JAMA Neurology, 71*(4), 499-504. doi:10.1001/jamaneurol.2013.6233

Tomlinson, C. L., Stowe, R., Patel, S., Rick, C., Gray, R., & Clarke, C. E. (2010). Systematic review of levodopa dose equivalency reporting in Parkinson's disease. *Mov Disord, 25*(15), 2649-2653. doi:10.1002/mds.23429

Troeung, L., Egan, S., & Gasson, N. (2013). A meta-analysis of randomized placebo-controlled treatment trials for depression and anxiety in Parkinson's disease.

Troeung, L., Egan, S., & Gasson, N. (2014). A waitlist-controlled trial of group cognitive behavioural therapy for depression and anxiety in Parkinson's disease. *BMC Psychiatry, 14*, 19-19. doi:10.1186/1471-244X-14-19

Tuvblad, C., Gao, Y., Wang, P., Raine, A., Botwick, T., & Baker, L. A. (2013). The genetic and environmental etiology of decision-making: A longitudinal twin study. *Journal of Adolescence, 36*(2), 245-255. doi:10.1016/j.adolescence.2012.10.006

Upton, D. J., Bishara, A. J., Ahn, W.-Y., & Stout, J. C. (2011). Propensity for risk taking and trait impulsivity in the Iowa Gambling Task. *Personality and Individual Differences, 50*(4), 492-495. doi:10.1016/j.paid.2010.11.013

Ursache, A., & Raver, C. C. (2015). Iowa Gambling Task performance and executive function predict low-income urban preadolescents' risky behaviors. *Personality and Individual Differences, 79*, 1-6. doi:10.1016/j.paid.2015.01.010

Valentino, V., Iavarone, A., Amboni, M., Moschiano, F., Picillo, M., Petretta, V., & Cicarelli, G. (2018). Apathy in Parkinson's disease: differences between caregiver's report and self-evaluation. *Functional Neurology, 33*(1), 31-35. doi:10.11138/FNeur/2018.33.1.031

Valk, S. L., Bernhardt, B. C., Böckler, A., Kanske, P., & Singer, T. (2016). Substrates of metacognition on perception and metacognition on higher-order cognition relate to different subsystems of the mentalizing network. *Human Brain Mapping, 37*(10), 3388-3399. doi:10.1002/hbm.23247

Van Camp, L. S. C., Sabbe, B. G. C., & Oldenburg, J. F. E. (2017). Cognitive insight: A systematic review. *Clinical Psychology Review, 55*, 12-24. doi:10.1016/j.cpr.2017.04.011

Van Den Eeden, S. K., Tanner, C. M., Bernstein, A. L., Fross, R. D., Leimpeter, A., Bloch, D. A., & Nelson, L. M. (2003). Incidence of Parkinson's disease: Variation by age, gender, and race/ethnicity. *American Journal of Epidemiology, 157*(11), 1015-1022. doi:10.1093/aje/kwg068

van der Meer, L., de Vos, A. E., Stiekema, A. P. M., Pijnenborg, G. H. M., van Tol, M.-J., Nolen, W. A., . . . Aleman, A. (2013). Insight in schizophrenia: Involvement of self-

reflection networks? *Schizophrenia Bulletin, 39*(6), 1288-1295. doi:10.1093/schbul/sbs122

van der Vegt, J. P. M., Hulme, O. J., Zittel, S., Madsen, K. H., Weiss, M. M., Buhmann, C., . . . Siebner, H. R. (2013). Attenuated neural response to gamble outcomes in drug-naive patients with Parkinson's disease. *Brain, 136*(4), 1192-1203. doi:10.1093/brain/awt027

Verdejo-Garcia, A., Benbrook, A., Funderburk, F., David, P., Cadet, J.-L., & Bolla, K. I. (2007). The differential relationship between cocaine use and marijuana use on decision-making performance over repeat testing with the Iowa Gambling Task. *Drug and Alcohol Dependence, 90*(1), 2-11. doi:10.1016/j.drugalcdep.2007.02.004

Verdejo-García, A., Lawrence, A. J., & Clark, L. (2008). Impulsivity as a vulnerability marker for substance-use disorders: Review of findings from high-risk research, problem gamblers and genetic association studies. *Neuroscience & Biobehavioral Reviews, 32*(4), 777-810. doi:10.1016/j.neubiorev.2007.11.003

Vitale, C., Santangelo, G., Trojano, L., Verde, F., Rocco, M., Grossi, D., & Barone, P. (2011). Comparative neuropsychological profile of pathological gambling, hypersexuality, and compulsive eating in Parkinson's disease. *Movement Disorders, 26*(5), 830-836. doi:10.1002/mds.23567

Volz-Sidiropoulou, E., & Gauggel, S. (2012). Do subjective measures of attention and memory predict actual performance? Metacognition in older couples. *Psychology and Aging, 27*(2), 440-450. doi:10.1037/a0025384

Voon, V., Gao, J., Brezing, C., Symmonds, M., Ekanayake, V., Fernandez, H., . . . Hallett, M. (2011). Dopamine agonists and risk: impulse control disorders in Parkinson's disease. *Brain, 134*(5), 1438-1446. doi:10.1093/brain/awr080

Voon, V., Pessiglione, M., Brezing, C., Gallea, C., Fernandez, H. H., Dolan, R. J., & Hallett, M. (2010). Mechanisms underlying dopamine-mediated reward bias in compulsive behaviors. *Neuron, 65*(1), 135-142. doi:10.1016/j.neuron.2009.12.027

Voon, V., Sohr, M., Lang, A. E., Potenza, M. N., Siderowf, A. D., Whetteckey, J., . . . Stacy, M. (2011). Impulse control disorders in parkinson disease: A multicenter case–control study. *Annals of Neurology, 69*(6), 986-996. doi:10.1002/ana.22356

Voon, V., Thomsen, T., Miyasaki, J. M., de Souza, M., Shafro, A., Fox, S. H., . . . Zurowski, M. (2007). Factors associated with dopaminergic drug–related pathological gambling in Parkinson disease. *Archives of Neurology, 64*(2), 212-216. doi:10.1001/archneur.64.2.212

Voon, V., Thomsen, T., Miyasaki, J. M., & et al. (2007). Factors associated with dopaminergic drug–related pathological gambling in parkinson disease. *Archives of Neurology, 64*(2), 212-216. doi:10.1001/archneur.64.2.212

Wagle Shukla, A., Shuster, J. J., Chung, J. W., Vaillancourt, D. E., Patten, C., Ostrem, J., & Okun, M. S. (2016). Repetitive transcranial magnetic stimulation (rTMS) therapy in Parkinson disease: A meta-analysis. *PM&R, 8*(4), 356-366. doi:10.1016/j.pmrj.2015.08.009

Wagle Shukla, A., & Vaillancourt, D. E. (2014). Treatment and physiology in Parkinson's disease and dystonia: Using transcranial magnetic stimulation to uncover the mechanisms of action. *Current Neurology and Neuroscience Reports, 14*(6), 449. doi:10.1007/s11910-014-0449-5

Wang, K. S., Smith, D. V., & Delgado, M. R. (2016). Using fMRI to study reward processing in humans: past, present, and future. *Journal of Neurophysiology, 115*(3), 1664-1678. doi:10.1152/jn.00333.2015

Weafer, J., Baggott, M. J., & De Wit, H. (2013). Test–retest reliability of behavioral measures of impulsive choice, impulsive action, and inattention. *Experimental and Clinical Psychopharmacology, 21*(6), 475-481. doi:10.1037/a0033659

Webster, G. D., DeWall, C. N., Pond, R. S., Deckman, T., Jonason, P. K., Le, B. M., . . . Bator, R. J. (2014). The brief aggression questionnaire: Psychometric and behavioral evidence for an efficient measure of trait aggression. *Aggressive Behavior, 40*(2), 120-139. doi:10.1002/ab.21507

Webster, G. D., DeWall, C. N., Pond, R. S., Deckman, T., Jonason, P. K., Le, B. M., . . . Bator, R. J. (2015). The brief aggression questionnaire: Structure, validity, reliability, and generalizability. *Journal of Personality Assessment*, 1-12. doi:10.1080/00223891.2015.1044093

Weintraub, D. (2019). Impulse control disorders in Parkinson's disease: A 20-year odyssey. *Movement Disorders, 34*(4), 447-452. doi:10.1002/mds.27668

Weintraub, D., David, A. S., Evans, A. H., Grant, J. E., & Stacy, M. (2015). Clinical spectrum of impulse control disorders in Parkinson's disease. *Movement Disorders, 30*(2), 121-127. doi:10.1002/mds.26016

Weintraub, D., Hoops, S., Shea, J., Lyons, K., Pahwa, R., Driver-Dunckley, E., . . . Voon, V. (2009). Validation of the questionnaire for impulsive-compulsive disorders in Parkinson's disease. *Movement Disorders, 24*(10), 1461-1467. doi:10.1002/mds.22571

Weintraub, D., Koester, J., Potenza, M. N., Siderowf, A. D., Stacy, M., Voon, V., . . . Lang, A. E. (2010). Impulse control disorders in Parkinson disease: A cross-sectional study of 3090 patients. *Archives of Neurology, 67*(5), 589-595. doi:10.1001/archneurol.2010.65

Weintraub, D., Mamikonyan, E., Papay, K., Shea, J. A., Xie, S. X., & Siderowf, A. (2012). Questionnaire for impulsive-compulsive disorders in Parkinson's disease–rating scale. *Movement Disorders, 27*(2), 242-247. doi:10.1002/mds.24023

Weintraub, D., Siderowf, A. D., & Potenza, M. N. (2006). Association of dopamine agonist use with impulse control disorders in parkinson disease. *Archives of Neurology, 63*(7), 969-973. doi:10.1001/archneur.63.7.969

Wen, M., Zhou, B., Chen, Y.-H., Ma, Z.-L., Gou, Y., Zhang, C.-L., . . . Jiao, L. (2017). Serum uric acid levels in patients with Parkinson's disease: A meta-analysis. *PLoS ONE, 12*(3), e0173731. doi:10.1371/journal.pone.0173731

White, T. L., Lejuez, C. W., & de Wit, H. (2008). Test-retest characteristics of the Balloon Analogue Risk Task (BART). *Experimental & Clinical Psychopharmacology, 16*(6), 565-570. doi:10.1037/a0014083

Whitehouse, P. J., Hedreen, J. C., White, C. L., & Price, D. L. (1983). Basal forebrain neurons in the dementia of Parkinson disease. *Annals of Neurology, 13*(3), 243-248. doi:10.1002/ana.410130304

Whiteside, S. P., & Lynam, D. R. (2001). The Five Factor Model and impulsivity: using a structural model of personality to understand impulsivity. *Personality and Individual Differences, 30*(4), 669-689. doi:10.1016/S0191-8869(00)00064-7

Whiteside, S. P., Lynam, D. R., Miller, J. D., & Reynolds, S. K. (2005). Validation of the UPPS impulsive behaviour scale: a four-factor model of impulsivity. *European Journal of Personality, 19*(7), 559-574. doi:10.1002/per.556

Wilbertz, G., Tebartz van Elst, L., Delgado, M. R., Maier, S., Feige, B., Philipsen, A., & Blechert, J. (2012). Orbitofrontal reward sensitivity and impulsivity in adult attention deficit hyperactivity disorder. *NeuroImage, 60*(1), 353-361. doi:10.1016/j.neuroimage.2011.12.011

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the executive function theory of Attention-Deficit/Hyperactivity Disorder: A meta-analytic review. *Biological Psychiatry, 57*(11), 1336-1346. doi:10.1016/j.biopsych.2005.02.006

Wirdefeldt, K., Adami, H.-O., Cole, P., Trichopoulos, D., & Mandel, J. (2011). Epidemiology and etiology of Parkinson's disease: a review of the evidence. *European Journal of Epidemiology, 26*(1), 1. doi:10.1007/s10654-011-9581-6

Witjas, T., Kaphan, E., Azulay, J. P., Blin, O., Ceccaldi, M., Pouget, J., . . . Chérif, A. A. (2002). Nonmotor fluctuations in Parkinson's disease. *Neurology, 59*(3), 408. doi:10.1212/WNL.59.3.408

Witthöft, M., Kerstner, T., Ofer, J., Mier, D., Rist, F., Diener, C., & Bailer, J. (2015). Cognitive biases in pathological health anxiety: The contribution of attention,

memory, and evaluation processes. *Clinical Psychological Science, 4*(3), 464-479. doi:10.1177/2167702615593474

Wood, R. L., & Thomas, R. H. (2013). Impulsive and episodic disorders of aggressive behaviour following traumatic brain injury. *Brain Injury, 27*(3), 253-261. doi:10.3109/02699052.2012.743181

Woods, D. T., & Kneebone, A. C. (2016). Memory problems in parkinson's disease patients with and without mild cognitive impairment: Comparisons between caregiver and self-report. *Movement Disorders Clinical Practice, 4*(3), 430-436. doi:10.1002/mdc3.12452

Wright, B. A., & Waters, C. H. (2013). Continuous dopaminergic delivery to minimize motor complications in Parkinson's disease. *Expert Review of Neurotherapeutics, 13*(6), 719-729. doi:10.1586/ern.13.47

Xu, Q., Park, Y., Huang, X., Hollenbeck, A., Blair, A., Schatzkin, A., & Chen, H. (2010). Physical activities and future risk of Parkinson disease. *Neurology, 75*(4), 341. doi:10.1212/WNL.0b013e3181ea1597

Xu, S., Korczykowski, M., Zhu, S., & Rao, H. (2013). Assessment of risk-taking and impulsive behaviors: A comparison between three tasks. *Social behavior and personality, 41*(3), 477. doi:10.2224/sbp.2013.41.3.477

Ye, B. S., Jeon, S., Yoon, S., Kang, S. W., Baik, K., Lee, Y., . . . Sohn, Y. H. (2018). Effects of dopaminergic depletion and brain atrophy on neuropsychiatric symptoms in de novo Parkinson's disease. *Journal of neurology, neurosurgery, and psychiatry, 89*(2), 197. doi:10.1136/jnnp-2017-316075

Yoo, H. S., Yun, H. J., Chung, S. J., Sunwoo, M. K., Lee, J.-M., Sohn, Y. H., & Lee, P. H. (2015). Patterns of neuropsychological profile and cortical thinning in parkinson's disease with punding. *PLoS ONE, 10*(7), e0134468. doi:10.1371/journal.pone.0134468

Yu, R.-L., & Wu, R.-M. (2013). Social brain dysfunctions in patients with Parkinson's disease: a review of theory of mind studies. *Translational Neurodegeneration, 2*, 7-7. doi:10.1186/2047-9158-2-7

Zarow, C., Lyness, S. A., Mortimer, J. A., & Chui, H. C. (2003). Neuronal loss is greater in the locus coeruleus than nucleus basalis and substantia nigra in alzheimer and parkinson diseases. *Archives of Neurology, 60*(3), 337-341. doi:10.1001/archneur.60.3.337

Zhang, G., Zhang, Z., Liu, L., Yang, J., Huang, J., Xiong, N., & Wang, T. (2014). Impulsive and compulsive behaviors in Parkinson's disease. *Frontiers in Aging Neuroscience, 6*(318). doi:10.3389/fnagi.2014.00318

Zhang, L., Opmeer, E. M., Ruhé, H. G., Aleman, A., & van der Meer, L. (2015). Brain activation during self- and other-reflection in bipolar disorder with a history of psychosis: Comparison to schizophrenia. *NeuroImage: Clinical, 8*, 202-209. doi:10.1016/j.nicl.2015.04.010

Zhang, S., Dissanayaka, N. N., Dawson, A., O'Sullivan, J. D., Mosley, P., Hall, W., & Carter, A. (2016). Management of impulse control disorders in Parkinson's disease. *28*(10), 1597-1614. doi:10.1017/S104161021600096X

Zuckerman, M. (1971). Dimensions of sensation seeking. *Journal of Consulting and Clinical Psychology, 36*(1), 45-52. doi:10.1037/h0030478

Appendices

Appendix A: Demographic Questionnaire

Demographic Questionnaire

Today's Date: _____ / _____ /_____

A. Demographic Information

Age: _____ (years) Gender: M / F (please circle)

Nationality: _____

Relationship status: (please circle)

Single In a relationship De facto Engaged

Married Separated Divorced Widowed

Other: _____

B. Parkinson's Disease History

How old were you when you:

First noticed signs of PD?_____years

Were *formally diagnosed* with PD?_____years By who? _____
(e.g., GP, neurologist, etc.)

Do any of your relatives have or have had PD? Yes / No
If yes, what relation are/were they to you?

1. _____ 2._____

3. _____ 4. _____

C. General Medical History

Do you have a medical condition (s) other than Parkinson's? Yes / No

If yes, what condition(s)?

_____

_____

_____

Are you currently taking any medication for these conditions? Yes / No

If yes, please specify the **type of medication** and **which condition it is used for**:

What medication do you currently take?	mg of medication per tablet	Number of tablets per day	What condition is the medication taken/prescribed for?
1.			
2.			
3.			
4.			
5.			
6			

D. Psychiatric History

Have you ever been diagnosed with a psychological disorder? Yes / No

If so, was it: (please circle)

Depression	Anxiety	Schizophrenia
Bipolar Disorder	Personality Disorder	Impulse Control Disorder

Other (please specify) _____

When were you diagnosed? Year _____ Month _____

What type of treatments were/are you receiving (psychotherapy, medications etc)?

_____

_____

_____

E. Dopamine Agonists

Current use

Are you currently taking any of these drugs? If so, can you please indicate how long you have been taking the drug(s)

Name of Drug	Yes (tick)	Duration
Sifrol, Sifrol ER, or Simipex (Pramipexole)		Years_____ Months _____
Neupro (Rotigotine)		Years_____ Months _____
Apomine or Movapo (Apomorphine)		Years_____ Months _____
Permax (Pergolide)		Years_____ Months _____
Cabaser (Cabergoline)		Years_____ Months _____
Parlodel or Kripton (Bromocriptine)		Years_____ Months _____

Past use

Have you ever taken any of these drugs in the past? If so, please indicate how long you took the drug(s) before you stopped? Also on the next page please describe why you came off the drug.

Name of Drug	Yes (tick)	Duration
Sifrol, Sifrol ER, or Simipex (Pramipexole)		Years_____ Months _____
Neupro (Rotigotine)		Years_____ Months _____
Apomine or Movapo (Apomorphine)		Years_____ Months _____
Permax (Pergolide)		Years_____ Months _____
Cabaser (Cabergoline)		Years_____ Months _____
Parlodel or Kripton (Bromocriptine)		Years_____ Months _____

If you did take any of these drugs in the past (ticked yes in the previous table), could you please describe why you came off them.

_____

_____

_____

_____

_____

_____

F. Please list the Parkinsonian medications that you currently take in the table below

What anti-Parkinson's medication do you currently take?	mg of medication per tablet	Number of tablets per dose	Number of dosages per day	When (e.g., 7am. 11am, 3pm)
1.				
2.				
3.				
4.				
5.				
6.				

When did you start taking anti- Parkinson's medication? (e.g., 2012 March)

Year _____ Month_____

Have you maintained a stable dose of antiparkinsonian medication for the past 2 months?

Y / N (please circle)

Appendix B: Telephone Interview for Cognitive Status-30

Telephone Interview for Cognitive Status-30

Item #	Question	Score	Total
1	**What year is this?**	1	Max 5
	What season is this?	1	
	What month of the year is this?	1	
	What is today's date?	1	
	What day of the week is this?	1	
2	**What country are we in?**	1	Max 3
	What state are we in?	1	
	What city are we in?	1	
3	**Count backwards from 20 to 1.**		Max 2
	Completely correct on first trial	2	
	Completely correct on second trial	1	
	Any other responses	0	
4	**I'm going to read you a list of 10 words. Please listen carefully and try to remember them. When I'm done, tell me as many words as you can, in any order.**		Max 10
	Cabin	1	
	Pipe	1	
	Elephant	1	
	Chest	1	
	Silk	1	
	Theatre	1	
	Watch	1	
	Whip	1	
	Pillow	1	
	Giant	1	
5	**Please spell the word WORLD backwards**		Max 5
	Correct response: DLROW	5	
	Omission of one letter (eg, DLRW, DLOW, DROW, DLRO)	4	
	Omission of two letters (eg DLR, LRO, DLW) or Reversal of two letters (eg DLORW, DRLOW, DLRWO, DLWOR)	3	
	Omission/reversal of three letters (eg DORLW, DL, OW)	2	
	Reversal of four letters (eg DRLWO, LDRWO)	1	
	Cannot spell backwards even with assistance	0	
6	**What do people usually use to cut paper?** (Scissors, shears)	1	Max 2
	How many things are in a dozen? (12)	1	
7	**Please repeat this phrase: 'No ifs, ands or buts'**		Max 1
	Complete repetition on first trial	1	
8	**Who is the Prime Minister of Australia right now?**		Max 2
	Full name or first or last name acceptable (ie Tony Abbott, Tony, Abbott)	1	
	Who is the president of the United States right now?		
	Full name or first or last name acceptable (ie Barack Obama, Barack, Obama)	1	
	Total Score: (max 30)		

Appendix C: Movement Disorder Society Revision of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS) Section III

Part III: Motor Examination

Overview: This portion of the scale assesses the motor signs of PD. In administering Part III of the MDS-UPDRS the examiner should comply with the following guidelines:

At the top of the form, mark whether the patient is on medication for treating the symptoms of Parkinson's disease and, if on levodopa, the time since the last dose.

Also, if the patient is receiving medication for treating the symptoms of Parkinson's Disease, mark the patient's clinical state using the following definitions:
ON is the typical functional state when patients are receiving medication and have a good response.
OFF is the typical functional state when patients have a poor response in spite of taking medications.

The investigator should "rate what you see". Admittedly, concurrent medical problems such as stroke, paralysis, arthritis, contracture, and orthopedic problems such as hip or knee replacement and scoliosis may interfere with individual items in the motor examination. In situations where it is absolutely impossible to test (e.g., amputations, plegia, limb in a cast), use the notation "**UR**" for Unable to Rate. Otherwise, rate the performance of each task as the patient performs in the context of co-morbidities.

All items must have an integer rating (no half points, no missing ratings).

Specific instructions are provided for the testing of each item. These should be followed in all instances. The investigator demonstrates while describing tasks the patient is to perform and rates function immediately thereafter. For Global Spontaneous Movement and Rest Tremor items (3.14 and 3.17), these items have been placed purposefully at the end of the scale because clinical information pertinent to the score will be obtained throughout the entire examination.

At the end of the rating, indicate if dyskinesia (chorea or dystonia) was present at the time of the examination, and if so, whether these movements interfered with the motor examination.

3a Is the patient on medication for treating the symptoms of Parkinson's Disease? ☐ No ☐ Yes

3b If the patient is receiving medication for treating the symptoms of Parkinson's Disease, mark the patient's clinical state using the following definitions:

☐ ON: On is the typical functional state when patients are receiving medication and have a good response.

☐ OFF: Off is the typical functional state when patients have a poor response in spite of taking medications.

3c Is the patient on Levodopa ? ☐ No ☐ Yes

3.C1 If yes, minutes since last levodopa dose: _____

	SCORE
3.1 SPEECH Instructions to examiner: Listen to the patient's free-flowing speech and engage in conversation if necessary. Suggested topics: ask about the patient's work, hobbies, exercise, or how he got to the doctor's office. Evaluate volume, modulation (prosody) and clarity, including slurring, palilalia (repetition of syllables) and tachyphemia (rapid speech, running syllables together). 0: Normal: No speech problems. 1: Slight: Loss of modulation, diction or volume, but still all words easy to understand. 2: Mild: Loss of modulation, diction, or volume, with a few words unclear, but the overall sentences easy to follow. 3: Moderate: Speech is difficult to understand to the point that some, but not most, sentences are poorly understood. 4: Severe: Most speech is difficult to understand or unintelligible.	☐
3.2 FACIAL EXPRESSION Instructions to examiner: Observe the patient sitting at rest for 10 seconds, without talking and also while talking. Observe eye-blink frequency, masked facies or loss of facial expression, spontaneous smiling and parting of lips. 0: Normal: Normal facial expression. 1: Slight: Minimal masked facies manifested only by decreased frequency of blinking. 2: Mild: In addition to decreased eye-blink frequency, Masked facies present in the lower face as well, namely fewer movements around the mouth, such as less spontaneous smiling, but lips not parted. 3: Moderate: Masked facies with lips parted some of the time when the mouth is at rest. 4: Severe: Masked facies with lips parted most of the time when the mouth is at rest.	☐

	SCORE
3.3 RIGIDITY Instructions to examiner: Rigidity is judged on slow passive movement of major joints with the patient in a relaxed position and the examiner manipulating the limbs and neck. First, test without an activation maneuver. Test and rate neck and each limb separately. For arms, test the wrist and elbow joints simultaneously. For legs, test the hip and knee joints simultaneously. If no rigidity is detected, use an activation maneuver such as tapping fingers, fist opening/closing, or heel tapping in a limb not being tested. Explain to the patient to go as limp as possible as you test for rigidity. 0: Normal: No rigidity. 1: Slight: Rigidity only detected with activation maneuver. 2: Mild: Rigidity detected without the activation maneuver, but full range of motion is easily achieved. 3: Moderate: Rigidity detected without the activation maneuver; full range of motion is achieved with effort. 4: Severe: Rigidity detected without the activation maneuver and full range of motion not achieved.	☐ Neck ☐ RUE ☐ LUE ☐ RLE ☐ LLE
3.4 FINGER TAPPING Instructions to examiner: Each hand is tested separately. Demonstrate the task, but do not continue to perform the task while the patient is being tested. Instruct the patient to tap the index finger on the thumb 10 times as quickly AND as big as possible. Rate each side separately, evaluating speed, amplitude, hesitations, halts and decrementing amplitude. 0: Normal: No problems. 1: Slight: Any of the following: a) the regular rhythm is broken with one or two interruptions or hesitations of the tapping movement; b) slight slowing; c) the amplitude decrements near the end of the 10 taps. 2: Mild: Any of the following: a) 3 to 5 interruptions during tapping; b) mild slowing; c) the amplitude decrements midway in the 10-tap sequence. 3: Moderate: Any of the following: a) more than 5 interruptions during tapping or at least one longer arrest (freeze) in ongoing movement; b) moderate slowing; c) the amplitude decrements starting after the 1st tap. 4: Severe: Cannot or can only barely perform the task because of slowing, interruptions or decrements.	☐ R ☐ L

	SCORE
3.5 HAND MOVEMENTS Instructions to examiner: Test each hand separately. Demonstrate the task, but do not continue to perform the task while the patient is being tested. Instruct the patient to make a tight fist with the arm bent at the elbow so that the palm faces the examiner. Have the patient open the hand 10 times as fully AND as quickly as possible. If the patient fails to make a tight fist or to open the hand fully, remind him/her to do so. Rate each side separately, evaluating speed, amplitude, hesitations, halts and decrementing amplitude. 0: Normal: No problem. 1: Slight: Any of the following: a) the regular rhythm is broken with one or two interruptions or hesitations of the movement; b) slight slowing; c) the amplitude decrements near the end of the task. 2: Mild: Any of the following: a) 3 to 5 interruptions during the movements; b) mild slowing; c) the amplitude decrements midway in the task. 3: Moderate: Any of the following: a) more than 5 interruptions during the movement or at least one longer arrest (freeze) in ongoing movement; b) moderate slowing; c) the amplitude decrements starting after the 1st open-and-close sequence. 4: Severe: Cannot or can only barely perform the task because of slowing, interruptions or decrements.	☐ R ☐ L
3.6 PRONATION-SUPINATION MOVEMENTS OF HANDS Instructions to examiner: Test each hand separately. Demonstrate the task, but do not continue to perform the task while the patient is being tested. Instruct the patient to extend the arm out in front of his/her body with the palms down; then to turn the palm up and down alternately 10 times as fast and as fully as possible. Rate each side separately, evaluating speed, amplitude, hesitations, halts and decrementing amplitude. 0: Normal: No problems. 1: Slight: Any of the following: a) the regular rhythm is broken with one or two interruptions or hesitations of the movement; b) slight slowing; c) the amplitude decrements near the end of the sequence. 2: Mild: Any of the following: a) 3 to 5 interruptions during the movements; b) mild slowing; c) the amplitude decrements midway in the sequence. 3: Moderate: Any of the following: a) more than 5 interruptions during the movement or at least one longer arrest (freeze) in ongoing movement; b) moderate slowing c) the amplitude decrements starting after the 1st supination-pronation sequence. 4: Severe: Cannot or can only barely perform the task because of slowing, interruptions or decrements.	☐ R ☐ L

	SCORE
3.7 TOE TAPPING Instructions to examiner: Have the patient sit in a straight-backed chair with arms, both feet on the floor. Test each foot separately. Demonstrate the task, but do not continue to perform the task while the patient is being tested. Instruct the patient to place the heel on the ground in a comfortable position and then tap the toes 10 times as big and as fast as possible. Rate each side separately, evaluating speed, amplitude, hesitations, halts and decrementing amplitude. 0: Normal: No problem. 1: Slight: Any of the following: a) the regular rhythm is broken with one or two interruptions or hesitations of the tapping movement; b) slight slowing; c) amplitude decrements near the end of the ten taps. 2: Mild: Any of the following: a) 3 to 5 interruptions during the tapping movements; b) mild slowing; c) amplitude decrements midway in the task. 3: Moderate: Any of the following: a) more than 5 interruptions during the tapping movements or at least one longer arrest (freeze) in ongoing movement; b) moderate slowing; c) amplitude decrements after the first tap. 4: Severe: Cannot or can only barely perform the task because of slowing, interruptions or decrements.	☐ R ☐ L
3.8 LEG AGILITY Instructions to examiner: Have the patient sit in a straight-backed chair with arms. The patient should have both feet comfortably on the floor. Test each leg separately. Demonstrate the task, but do not continue to perform the task while the patient is being tested. Instruct the patient to place the foot on the ground in a comfortable position and then raise and stomp the foot on the ground 10 times as high and as fast as possible. Rate each side separately, evaluating speed, amplitude, hesitations, halts and decrementing amplitude. 0: Normal: No problems. 1: Slight: Any of the following: a) the regular rhythm is broken with one or two interruptions or hesitations of the movement; b) slight slowing; c) amplitude decrements near the end of the task. 2: Mild: Any of the following: a) 3 to 5 interruptions during the movements; b) mild slowness; c) amplitude decrements midway in the task. 3: Moderate: Any of the following: a) more than 5 interruptions during the movement or at least one longer arrest (freeze) in ongoing movement; b) moderate slowing in speed; c) amplitude decrements after the first tap. 4: Severe: Cannot or can only barely perform the task because of slowing, interruptions or decrements.	☐ R ☐ L

	SCORE
3.9 ARISING FROM CHAIR Instructions to examiner: Have the patient sit in a straight-backed chair with arms, with both feet on the floor and sitting back in the chair (if the patient is not too short). Ask the patient to cross his/her arms across the chest and then to stand up. If the patient is not successful, repeat this attempt a maximum up to two more times. If still unsuccessful, allow the patient to move forward in the chair to arise with arms folded across the chest. Allow only one attempt in this situation. If unsuccessful, allow the patient to push off using his/her hands on the arms of the chair. Allow a maximum of three trials of pushing off. If still not successful, assist the patient to arise. After the patient stands up, observe the posture for item 3.13 0: Normal: No problems. Able to arise quickly without hesitation. 1: Slight: Arising is slower than normal; or may need more than one attempt; or may need to move forward in the chair to arise. No need to use the arms of the chair. 2: Mild: Pushes self up from arms of chair without difficulty. 3: Moderate: Needs to push off, but tends to fall back; or may have to try more than one time using arms of chair, but can get up without help. 4: Severe: Unable to arise without help.	☐
3.10 GAIT Instructions to examiner: Testing gait is best performed by having the patient walking away from and towards the examiner so that both right and left sides of the body can be easily observed simultaneously. The patient should walk at least 10 meters (30 feet), then turn around and return to the examiner. This item measures multiple behaviors: stride amplitude, stride speed, height of foot lift, heel strike during walking, turning, and arm swing, but not freezing. Assess also for "freezing of gait" (next item 3.11) while patient is walking. Observe posture for item 3.13 0: Normal: No problems. 1: Slight: Independent walking with minor gait impairment. 2: Mild: Independent walking but with substantial gait impairment. 3: Moderate: Requires an assistance device for safe walking (walking stick, walker) but not a person. 4: Severe: Cannot walk at all or only with another person's assistance.	☐

	SCORE
3.11 FREEZING OF GAIT Instructions to examiner: While assessing gait, also assess for the presence of any gait freezing episodes. Observe for start hesitation and stuttering movements especially when turning and reaching the end of the task. To the extent that safety permits, patients may NOT use sensory tricks during the assessment. 0: Normal: No freezing. 1: Slight: Freezes on starting, turning or walking through doorway with a single halt during any of these events, but then continues smoothly without freezing during straight walking. 2: Mild: Freezes on starting, turning or walking through doorway with more than one halt during any of these activities, but continues smoothly without freezing during straight walking. 3: Moderate: Freezes once during straight walking. 4: Severe: Freezes multiple times during straight walking.	☐
3.12 POSTURAL STABILITY Instructions to examiner: The test examines the response to sudden body displacement produced by a quick, forceful pull on the shoulders while the patient is standing erect with eyes open and feet comfortably apart and parallel to each other. Test retropulsion. Stand behind the patient and instruct the patient on what is about to happen. Explain that s/he is allowed to take a step backwards to avoid falling. There should be a solid wall behind the examiner, at least 1-2 meters away to allow for the observation of the number of retropulsive steps. The first pull is an instructional demonstration and is purposely milder and not rated. The second time the shoulders are pulled briskly and forcefully towards the examiner with enough force to displace the center of gravity so that patient MUST take a step backwards. The examiner needs to be ready to catch the patient, but must stand sufficiently back so as to allow enough room for the patient to take several steps to recover independently. Do not allow the patient to flex the body abnormally forward in anticipation of the pull. Observe for the number of steps backwards or falling. Up to and including two steps for recovery is considered normal, so abnormal ratings begin with three steps. If the patient fails to understand the test, the examiner can repeat the test so that the rating is based on an assessment that the examiner feels reflects the patient's limitations rather than misunderstanding or lack of preparedness. Observe standing posture for item 3.13 0: Normal: No problems: Recovers with one or two steps. 1: Slight: 3-5 steps, but subject recovers unaided. 2: Mild: More than 5 steps, but subject recovers unaided. 3: Moderate: Stands safely, but with absence of postural response; falls if not caught by examiner. 4: Severe: Very unstable, tends to lose balance spontaneously or with just a gentle pull on the shoulders.	☐

	SCORE
3.13 POSTURE Instructions to examiner: Posture is assessed with the patient standing erect after arising from a chair, during walking , and while being tested for postural reflexes. If you notice poor posture, tell the patient to stand up straight and see if the posture improves (see option 2 below). Rate the worst posture seen in these three observation points. Observe for flexion and side-to-side leaning. 0: Normal: No problems. 1: Slight: Not quite erect, but posture could be normal for older person. 2: Mild: Definite flexion, scoliosis or leaning to one side, but patient can correct posture to normal posture when asked to do so. 3: Moderate: Stooped posture, scoliosis or leaning to one side that cannot be corrected volitionally to a normal posture by the patient. 4: Severe: Flexion, scoliosis or leaning with extreme abnormality of posture.	☐
3.14 GLOBAL SPONTANEITY OF MOVEMENT (BODY BRADYKINESIA) Instructions to examiner: This global rating combines all observations on slowness, hesitancy, and small amplitude and poverty of movement in general, including a reduction of gesturing and of crossing the legs. This assessment is based on the examiner's global impression after observing for spontaneous gestures while sitting, and the nature of arising and walking. 0: Normal: No problems. 1: Slight: Slight global slowness and poverty of spontaneous movements. 2: Mild: Mild global slowness and poverty of spontaneous movements. 3: Moderate: Moderate global slowness and poverty of spontaneous movements. 4: Severe: Severe global slowness and poverty of spontaneous movements.	☐
3.15 POSTURAL TREMOR OF THE HANDS Instructions to examiner: All tremor, including re-emergent rest tremor, that is present in this posture is to be included in this rating. Rate each hand separately. Rate the highest amplitude seen. Instruct the patient to stretch the arms out in front of the body with palms down. The wrist should be straight and the fingers comfortably separated so that they do not touch each other. Observe this posture for 10 seconds. 0: Normal: No tremor. 1: Slight: Tremor is present but less than 1 cm in amplitude. 2: Mild: Tremor is at least 1 but less than 3 cm in amplitude. 3: Moderate: Tremor is at least 3 but less than 10 cm in amplitude. 4: Severe: Tremor is at least 10 cm in amplitude.	☐ R ☐ L

	SCORE
3.16 KINETIC TREMOR OF THE HANDS Instructions to examiner: This is tested by the finger-to-nose maneuver. With the arm starting from the outstretched position, have the patient perform at least three finger-to-nose maneuvers with each hand reaching as far as possible to touch the examiner's finger. The finger-to-nose maneuver should be performed slowly enough not to hide any tremor that could occur with very fast arm movements. Repeat with the other hand, rating each hand separately. The tremor can be present throughout the movement or as the tremor reaches either target (nose or finger). Rate the highest amplitude seen. 0: Normal: No tremor. 1: Slight: Tremor is present but less than 1 cm in amplitude. 2: Mild: Tremor is at least 1 but less than 3 cm in amplitude. 3: Moderate: Tremor is at least 3 but less than 10 cm in amplitude. 4: Severe: Tremor is at least 10 cm in amplitude.	☐ R ☐ L
3.17 REST TREMOR AMPLITUDE Instructions to examiner: This and the next item have been placed purposefully at the end of the examination to allow the rater to gather observations on rest tremor that may appear at any time during the exam, including when quietly sitting, during walking and during activities when some body parts are moving but others are at rest. Score the maximum amplitude that is seen at any time as the final score. Rate only the amplitude and not the persistence or the intermittency of the tremor. As part of this rating, the patient should sit quietly in a chair with the hands placed on the arms of the chair (not in the lap) and the feet comfortably supported on the floor for 10 seconds with no other directives. Rest tremor is assessed separately for all four limbs and also for the lip/jaw. Rate only the maximum amplitude that is seen at any time as the final rating. Extremity ratings 0: Normal: No tremor. 1: Slight.: < 1 cm in maximal amplitude. 2: Mild: > 1 cm but < 3 cm in maximal amplitude. 3: Moderate: 3 - 10 cm in maximal amplitude. 4: Severe: > 10 cm in maximal amplitude. Lip/Jaw ratings 0: Normal: No tremor. 1: Slight: < 1 cm in maximal amplitude. 2: Mild: > 1 cm but < 2 cm in maximal amplitude. 3: Moderate: > 2 cm but < 3 cm in maximal amplitude. 4: Severe: > 3 cm in maximal amplitude.	☐ RUE ☐ LUE ☐ RLE ☐ LLE ☐ Lip/Jaw

	SCORE
3.18 CONSTANCY OF REST TREMOR Instructions to examiner: This item receives one rating for all rest tremor and focuses on the constancy of rest tremor during the examination period when different body parts are variously at rest. It is rated purposefully at the end of the examination so that several minutes of information can be coalesced into the rating. 0: Normal: No tremor. 1: Slight: Tremor at rest is present < 25% of the entire examination period. 2: Mild: Tremor at rest is present 26-50% of the entire examination period. 3: Moderate: Tremor at rest is present 51-75% of the entire examination period. 4: Severe: Tremor at rest is present > 75% of the entire examination period.	☐
DYSKINESIA IMPACT ON PART III RATINGS A. Were dyskinesias (chorea or dystonia) present during examination? ☐ No ☐ Yes B. If yes, did these movements interfere with your ratings? ☐ No ☐ Yes	
HOEHN AND YAHR STAGE 0: Asymptomatic. 1: Unilateral involvement only. 2: Bilateral involvement without impairment of balance. 3: Mile to moderate involvement; some postural instability but physically independent; needs assistance to recover from pull test. 4: Severe disability; still able to walk or stand unassisted. 5: Wheelchair bound or bedridden unless aided.	☐

Appendix D: The Behavioural Inhibition System/Behavioural Activation System Scale

BIS/BAS

Each item of this questionnaire is a statement that a person may either agree with or disagree with. For each item, indicate how much you agree or disagree with what the item says. Please respond to all the items; do not leave any blank. Choose only one response to each statement. Please be as accurate and honest as you can be. Respond to each item as if it were the only item. That is, don't worry about being "consistent" in your responses. Choose from the following four response options:

1 = very true for me
2 = somewhat true for me
3 = somewhat false for me
4 = very false for me

1. A person's family is the most important thing in life.
2. Even if something bad is about to happen to me, I rarely experience fear or nervousness.
3. I go out of my way to get things I want.
4. When I'm doing well at something I love to keep at it.
5. I'm always willing to try something new if I think it will be fun.
6. How I dress is important to me.
7. When I get something I want, I feel excited and energized.
8. Criticism or scolding hurts me quite a bit.
9. When I want something I usually go all-out to get it.
10. I will often do things for no other reason than that they might be fun.

11. It's hard for me to find the time to do things such as get a haircut.
12. If I see a chance to get something I want I move on it right away.
13. I feel pretty worried or upset when I think or know somebody is angry at me.
14. When I see an opportunity for something I like I get excited right away.
15. I often act on the spur of the moment.
16. If I think something unpleasant is going to happen I usually get pretty "worked up."
17. I often wonder why people act the way they do.
18. When good things happen to me, it affects me strongly.
19. I feel worried when I think I have done poorly at something important.
20. I crave excitement and new sensations.

21. When I go after something I use a "no holds barred" approach.
22. I have very few fears compared to my friends.
23. It would excite me to win a contest.
24. I worry about making mistakes.

Items other than 2 and 22 are reverse-scored.

BAS Drive: 3, 9, 12, 21
BAS Fun Seeking: 5, 10, 15, 20
BAS Reward Responsiveness: 4, 7, 14, 18, 23

BIS: 2, 8, 13, 16, 19, 22, 24

Items 1, 6, 11, 17, are fillers.

The fact that there are three BAS-related scales and only one BIS-related scales was not planned or theoretically motivated. The factors emerged empirically, from an item set that was intended to capture diverse manifestations of the BAS, according to various theoretical statements. It is likely that a broader sampling of items on the BIS side would also have resulted in more than one scale. I do not encourage combining the BAS scales, however, because they do turn out to focus on different aspects of incentive sensitivity. In particular, Fun Seeking is known to have elements of impulsiveness that are not contained in the other scales.

Appendix E: The Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease–Rating Scale

Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease - Rating Scale (QUIP-RS)

Instruction Sheet

TIME FRAME
Either past 4 weeks or any 4-week period in a designated time frame

DESCRIPTION OF BEHAVIORS
A. Gambling (casinos, internet gambling, lotteries, scratch tickets, betting, or slot or poker machines)

B. Sex (making sexual demands on others, promiscuity, prostitution, change in sexual orientation, masturbation, internet or telephone sexual activities, or pornography)

C. Buying (too much of the same thing or things that you don't need or use)

D. Eating (eating larger amounts or different types of food than in the past, more rapidly than normal, until feeling uncomfortably full, or when not hungry)

E. Hobbyism (specific tasks, hobbies or other organized activities, such as writing, painting, gardening, repairing or dismantling things, collecting, computer use, working on projects, etc.)

F. Punding (repeating certain simple motor activities, such as cleaning, tidying, handling, examining, sorting, ordering, collecting, hoarding, or arranging objects, etc.)

G. Medication Use (consistently taking too much of your Parkinson's medications, or increasing on your own, without medical advice, your overall intake of Parkinson's medications)

FREQUENCY OF BEHAVIORS

Never	**(0) = not at all**
Rarely	**(1) = infrequently or 1 day/week**
Sometimes	**(2) = at times or 2-3 days/week**
Often	**(3) = most of the time or 4-5 days/week**
Very often	**(4) = nearly always or 6-7 days/week**

Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease - Rating Scale (QUIP-RS)

Reported by: _____ Patient _____ Informant _____ Patient and Informant

Patient / Subject: _____

Date: _____

1. How much do you think about the following behaviors (such as having trouble keeping thoughts out of your mind or feeling guilty)?

Gambling?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Sex?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Buying?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Eating?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Performing tasks or hobbies?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Repeating simple activities?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Taking your PD medications?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)

2. Do you have urges or desires for the following behaviors that you feel are excessive or cause you distress (including becoming restless or irritable when unable to participate in them)?

Gambling?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Sex?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Buying?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Eating?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Performing tasks or hobbies?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Repeating simple activities?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Taking your PD medications?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)

3. Do you have difficulty controlling the following behaviors (such as increasing them over time, or having trouble cutting down or stopping them)?

Gambling?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Sex?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Buying?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Eating?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Performing tasks or hobbies?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Repeating simple activities?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Taking your PD medications?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)

4. Do you engage in activities specifically to continue the following behaviors (such as hiding what you are doing, lying, hoarding things, borrowing from others, accumulating debt, stealing, or being involved in illegal acts)?

Gambling?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Sex?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Buying?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Eating?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Performing tasks or hobbies?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Repeating simple activities?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)
Taking your PD medications?	___Never(0)	___Rarely(1)	___Sometimes(2)	___Often(3)	___Very often(4)

Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease - Rating Scale (QUIP-RS)

Subject: _____

Date: _____

SCORING SHEET

A. Gambling	_____	**(0-16)**
B. Sex	_____	**(0-16)**
C. Buying	_____	**(0-16)**
D. Eating	_____	**(0-16)**
E. Hobbyism-Punding	_____	**(0-32)**
F. PD Medication Use	_____	**(0-16)**
Total ICD Score (A-D)	_____	**(0-64)**
Total QUIP-RS Score (A-F)	_____	**(0-112)**

Appendix F: Screening for Risky Behaviours Battery

Screening for Risky Behaviours Battery - SERB

Alcohol Consumption:

The Alcohol Use Disorders Identification Test- Consumption (Bradley et al., 2007).

The AUDIT-C is a brief version of the full AUDIT measure developed to identify issues with alcohol use (Saunders, Aasland, Babor, Fuente, & Grant, 1993). The AUDIT-C is effective in screening for alcohol misuse and focuses upon items relating to alcohol consumption (Bradley et al., 2007). Importantly for the proposed study the AUDIT-C has demonstrated efficacy in identifying issues with drinking in older adult populations (Gómez et al., 2006). Additionally by focussing upon consumption levels the assessment remains as objective as possible, requiring minimal introspection from the participant.

1. How often do you have a drink containing alcohol?

Never (0 points), Monthly or less (1 point), Two to four times a month (2 points), Two to three times a week (3 points), Four or more times a week (4 points)

2. How many drinks containing alcohol do you have on a typical day when you are drinking?

1 or 2 (0 points), 3 or 4 (1 point), 5 or 6 (2 points), 7 to 9 (3 points), 10 or more (4 points)

3. How often do you have six or more drinks on one occasion?

Never (0 points), Less than monthly (1 points), Monthly (2 points), Weekly (3 points), Daily or almost daily (4 point)

Tobacco Consumption:

The Heaviness of Smoking Index (HSI) created by Heatherton, Kozlowski, Frecker, Rickert, and Robinson (1989) is a brief version of the widely used Fagerstrom test of nicotine dependence. The HSI is a brief two item measure which has demonstrated predictive validity and adequate reliability (Borland, Yong, O'Connor, Hyland, & Thompson, 2010; Courvoisier & Etter, 2010). Again importantly this measure has been selected for its more objective nature, minimising the amount of interpretation needed on the participant's behalf. Note that if the participant does not smoke this section will be scored as a zero.

1. How soon after you wake up do you smoke your first cigarette?

After 60 minutes (1 point), 31-60 minutes (2 points), 6-30 minutes (3 points), within 5 minutes (4 points).

2. How many cigarettes/day do you smoke?

10 or less (1 point), 11-20 (2 points), 21-30 (3 points), 31 or more (4 points).

Drug Consumption:

Risk taking regarding drug use will be examined by asking the participant how many drug classes they have tried over the last 12 months. This method has previously been used by Lejuez et al. (2002).

1. Please indicate which (if any) of the following drug classes you have tried over the last 12 months

(a) marijuana, (b) stimulants, (c) cocaine, (d) hallucinogens, (e) opiates, (f) sedatives.

For each positive, a score of 1 will be assigned to provide a total indication of drug use.

Gambling:

There are three commonly used measures to identify pathological gambling: Victorian Gambling Screen (VGS), the Canadian Problem Gambling Index (CPGI) and the South Oaks Gambling Screen (SOGS) (McMillen & Wenzel, 2006). Of these the SOGS is the most widely used (Abbott & Volberg, 2006). Upon inspection of all these measures it is apparent that they are not particularly brief and require degree subjective interpretation on behalf of the participant. Therefore to screen for the frequency of gambling behaviour an adaption of question one from the SOGS will be used.

1. Please indicate which of the following type of gambling you have done in the last 12 months. For each type mark one answer.

Please mark 'X' to answer each statement	**Not at all (0 points)**	**Less than once a week (1 point)**	**Once a week or more (2 points)**
Played cards for money			
Bet on horses, dogs, or other animals			
Went to casinos (legal or otherwise)			
Played the numbers or bet on lotteries			
Played bingo			
Played the stock and/or commodities market			
Played slot machines, poker machines, or other gambling machines			
Bowled, shot pool, played golf, or some other game of skill for money			
Played pull tabs or "paper" games other than lotteries			
Some form of gambling not listed above (please specify) _____			

Violence/Aggression:

The Brief Aggression Questionnaire will be used (Webster et al., 2014). The measure is a shortened version of the Buss-Perry Aggression Questionnaire by. The BAQ has demonstrated convergent validity with similar measures and has an adequate test re-test reliability of r = .68-.80 (Webster et al., 2015). The measure does appear to require a degree of insight, but it is the most objective self-report measure available.

Scored on a 5-point scale ranging from 1 (extremely uncharacteristic of me) to 5 (extremely characteristic of me).

Physical Aggression

1. Given enough provocation, I may hit another person
2. If I have to resort to violence to protect my rights, I will
3. There are people who pushed me so far that we came to blows

Verbal Aggression

1. I tell my friends openly when I disagree with them
2. When people annoy me, I may tell them what I think of them
3. My friends say that I'm somewhat argumentative

Anger

1. I am an even-tempered person*
2. Sometimes I fly off the handle for no good reason
3. I have trouble controlling my temper

Hostility

1. Other people always seem to get the breaks
2. I sometimes feel that people are laughing at me behind my back
3. When people are especially nice, I wonder what they want

*Reverse coded

General Risky Behaviours:

The following questions have been developed from the Centres for Disease Control Youth Risk Behaviour Surveillance System. The questions are designed to identify general risk taking behaviours in daily life (Centers for Disease Control and Prevention, 2015). Previous studies have used questions taken from the Youth Risk Behaviour Surveillance System to identify more general risky behaviours (Braddock et al., 2011; Lejuez, Aklin, Zvolensky, & Pedulla, 2003). The survey items have been shown to have good reliability (Brener et al., 2002).

Note: Have been used as a binary outcome yes/no, or also as a Likert scale.

Over the Last 12 months have you engaged in any of the following behaviours

A. Never (0 points)
B. Rarely (1 point)
C. Sometimes (2 points)
D. Most of the time (3 points)
E. Always (4 points)

1. Used any illicit drug
2. Used prescription medication without having a prescription
3. Gambled for real money
4. Stolen anything
5. Been in a physical fight
6. Ridden in a car without wearing a seatbelt
7. Ridden a bicycle or motor cycle without a helmet
8. Been in a car when the driver has been under the influence of alcohol
9. Driven a car under the influence of alcohol
10. Use the phone whist driving (calling, texting, emailing, etc.)

Socially inappropriate comments/remarks

There is anecdotal evidence that some people with PD experience some social impairments being liable to making inappropriate comments or remarks (Yu & Wu, 2013). Research into other disorders with impulsivity issues such as Attention Deficit Hyperactivity Disorder (ADHD) have been known to have similar issues with social functioning (Bunford et al., 2015). These social issues in PD such as blurting out inappropriate remarks are thought to be a consequence of impaired prefrontal functioning associated with dopaminergic disruption in PD (Poletti, Enrici, Bonuccelli, & Adenzato, 2011).

To detect these behaviours the following questions have been adapted from Kurlan et al. (1996) and Campbell and Muncer (2009).

Over the Last 12 months have you engaged in any of the following behaviours

A. Never (0 points)
B. Rarely (1 point)
C. Sometimes (2 points)
D. Most of the time (3 points)
E. Always (4 points)

1. Made an inappropriate remark or comment in conversation.
2. Made a comment in conversation that you have later regretted.
3. Said something that has offended other people.
4. Said something that has made other people around you upset.
5. Had someone mention that something you have said is inappropriate.

Due to the degree of insight that the previous question may require (13-17) a measure of Theory of Mind has been included. Research has suggested that people with PD experiences deficits in Theory of Mind (Poletti et al., 2011). These deficits are thought to contribute towards the inappropriate remarks can be present in those with PD (Yu & Wu, 2013). Therefore the faux pas test developed by Stone, Baron-Cohen, and Knight (1998) will be administered to participant to have a more objective measurement of a participant tendency to make impulsive socially inappropriate comments.

Scoring

There are seven sections to the Screening for Risky Behaviours Battery. To give each risky behaviour an equal rating each section will be out of 10 points giving a maximum score of 70.

Alcohol consumption: ((Q1 + Q2 + Q3) / 12) x 10

Tobacco consumption: ((Q1 + Q2) / 8) x 10

Drug Consumption: ((a+b+c+d+e+f) / 6) x 10

Gambling: (Sum of gambling behaviours / 20) x 10

Violence/Aggression: (Sum of aggressive behaviours / 60) x 10

General Risky Behaviours: (Sum of risky behaviours / 40) x 10

Socially inappropriate comments/remarks: (Sum of behaviours / 20) x 10

Sum all of the sections to get a total score out of 70

Screening for Risky Behaviours Battery

The following questionnaire will ask about various behaviours that may or may not apply to you. Please answer the questions as honestly as you can. All answers that you provide will remain confidential and it is recommended that you complete the questionnaire in private.

Alcohol Consumption:

Please tick the box that best describes you.

Questions	0	1	2	3	4
1. How often do you have a drink containing alcohol?	Never	Monthly or less	2-4 times a month	2-3 times a week	4 or more times a week
2. How many drinks containing alcohol do you have on a typical day when you are drinking?	1 or 2	3 or 4	5 or 6	7 or 9	10 or more
3. How often do you have six or more drinks on one occasion?	Never	Less than Monthly	Monthly	Weekly	Daily

Tobacco Consumption:

Please tick the box that best describes you. If you do not smoke just tick the "N/A" box

Questions	0	1	2	3	4
1. How soon after you wake up do you smoke your first cigarette?	N/A	After 60 Minutes	31-60 minutes	6-30 minutes	Within 5 minutes
2. How many cigarettes/day do you smoke?	0	10 or less	11-20	21-30	31 or more

Drug Consumption:

Please indicate which (if any) of the following drug classes you have tried over the last 12 months by ticking the box next to the drug in question. If you have not taken any of these drugs tick the box at the bottom.

Drug	Tick this box
Marijuana, (weed, cannabis)	
Stimulants (methamphetamine, ice, etc.)	
Cocaine	
Hallucinogens, (LSD, magic mushrooms)	
Opiates (heroin)	
Sedatives (benzodiazepines, valium)	

Gambling:
Please indicate which of the following types of gambling you have done in the last 12 months. For each type mark one answer.

Please tick to answer each statement	**Not at all (0 points)**	**Less than once a week (1 point)**	**Once a week or more (2 points)**
Played cards for money			
Bet on horses, dogs, or other animals			
Went to casinos (legal or otherwise)			
Played the numbers or bet on lotteries			
Played bingo			
Played the stock and/or commodities market			
Played slot machines, poker machines, or other gambling machines			
Bowled, shot pool, played golf, or some other game of skill for money			
Played pull tabs or "paper" games other than lotteries			
Some form of gambling not listed above (please specify) _____			

Violence/Aggression: Please tick the appropriate box.

	Extremely uncharacteristic of me	Somewhat uncharacteristic	Neither uncharacteristic nor characteristic	Somewhat characteristic of me	Extremely characteristic of me
Given enough provocation, I may hit another person					
If I have to resort to violence to protect my rights, I will					
There are people who pushed me so far that we came to blows					
I tell my friends openly when I disagree with them					
When people annoy me, I may tell them what I think of them					
My friends say that I'm somewhat argumentative					
I am an even-tempered person					
Sometimes I fly off the handle for no good reason					
I have trouble controlling my temper					
Other people always seem to get the breaks					
I sometimes feel that people are laughing at me behind my back					
When people are especially nice, I wonder what they want					

General Behaviours:

Over the Last 12 months have you engaged in any of the following behaviours? Please tick the box that best applies to you.

Questions	**0**	**1**	**2**	**3**	**4**
	Never	Rarely	Sometimes	Most of the time	Always
Used any illicit drug					
Used prescription medication without having a prescription					
Gambled for real money					
Stolen anything					
Been in a physical fight					
Ridden in a car without wearing a seatbelt					
Ridden a bicycle or motor cycle without a helmet					
Been in a car when the driver has been under the influence of alcohol					
Driven a car under the influence of alcohol					
Use the phone whist driving (calling, texting, emailing, etc.)					

Socially inappropriate comments/remarks

Over the Last 12 months have you experienced any of the following? Please tick the box that best applies to you.

Questions	**0**	**1**	**2**	**3**	**4**
	Never	Rarely	Sometimes	Most of the time	Always
Made an inappropriate remark or comment in conversation.					
Made a comment in a conversation that you have later regretted.					
Said something that has offended other people.					
Said something that has made other people around you upset.					
Had someone mention that something you have said is inappropriate					

Reference List

Abbott, M. W., & Volberg, R. A. (2006). The measurement of adult problem and pathological gambling. *International Gambling Studies, 6*(2), 175-200. doi: 10.1080/14459790600928678

Borland, R., Yong, H.-H., O'Connor, R. J., Hyland, A., & Thompson, M. E. (2010). The reliability and predictive validity of the Heaviness of Smoking Index and its two components: Findings from the International Tobacco Control Four Country study. *Nicotine & Tobacco Research, 12*(suppl 1), S45-S50. doi: 10.1093/ntr/ntq038

Braddock, K. H., Dillard, J. P., Voigt, D. C., Stephenson, M. T., Sopory, P., & Anderson, J. W. (2011). Impulsivity partially mediates the relationship between BIS/BAS and risky health behaviors. *Journal of Personality, 79*(4), 793-810. doi: 10.1111/j.1467-6494.2011.00699.x

Bradley, K. A., DeBenedetti, A. F., Volk, R. J., Williams, E. C., Frank, D., & Kivlahan, D. R. (2007). AUDIT-C as a brief screen for alcohol misuse in primary care. *Alcoholism: Clinical and Experimental Research, 31*(7), 1208-1217. doi: 10.1111/j.1530-0277.2007.00403.x

Brener, N. D., Kann, L., McManus, T., Kinchen, S. A., Sundberg, E. C., & Ross, J. G. (2002). Reliability of the 1999 youth risk behavior survey questionnaire. *Journal of Adolescent Health, 31*(4), 336-342. doi: 10.1016/S1054-139X(02)00339-7

Bunford, N., Brandt, N., Golden, C., Dykstra, J., Suhr, J., & Owens, J. (2015). Attention-Deficit/Hyperactivity Disorder symptoms mediate the association between deficits in executive functioning and social impairment in children. *An official publication of the International Society for Research in Child and Adolescent Psychopathology, 43*(1), 133-147. doi: 10.1007/s10802-014-9902-9

Campbell, A., & Muncer, S. (2009). Can 'risky' impulsivity explain sex differences in aggression? *Personality and Individual Differences, 47*(5), 402-406. doi: 10.1016/j.paid.2009.04.006

Centers for Disease Control and Prevention. (2015). *Youth Risk Behavior Surveillance System.* Atlanta GA: Centers for Disease Control and Prevention.

Courvoisier, D. S., & Etter, J.-F. (2010). Comparing the predictive validity of five cigarette dependence questionnaires. *Drug and Alcohol Dependence, 107*(2–3), 128-133. doi: 10.1016/j.drugalcdep.2009.09.011

Gómez, A., Conde, A., Santana, J. M., Jorrín, A., Serrano, I. M., & Medina, R. (2006). The diagnostic usefulness of AUDIT and AUDIT-C for detecting hazardous drinkers in the elderly. *Aging & Mental Health, 10*(5), 558-561. doi: 10.1080/13607860600637729

Heatherton, T. F., Kozlowski, L. T., Frecker, R. C., Rickert, W., & Robinson, J. (1989). Measuring the Heaviness of Smoking: using self-reported time to the first cigarette of the day and number of cigarettes smoked per day. *British Journal of Addiction, 84*(7), 791-800. doi: 10.1111/j.1360-0443.1989.tb03059.x

Kurlan, R., Daragjati, C., Como, P. G., McDermott, M. P., Trinidad, K. S., Roddy, S., . . . Robertson, M. M. (1996). Non-obscene complex socially inappropriate behavior in Tourette's syndrome. *The Journal of Neuropsychiatry and Clinical Neurosciences, 8*(3), 311.

Lejuez, C. W., Aklin, W. M., Zvolensky, M. J., & Pedulla, C. M. (2003). Evaluation of the Balloon Analogue Risk Task (BART) as a predictor of adolescent real-world risk-taking behaviours. *Journal of Adolescence, 26*(4), 475-479. doi: 10.1016/S0140-1971(03)00036-8

Lejuez, C. W., Read, J. P., Kahler, C. W., Richards, J., Ramsey, S., Stuart, G., . . . Brown, R. (2002). Evaluation of a behavioral measure of risk taking: The Balloon Analogue Risk Task (BART). *Journal of Experimental Psychology: Applied, 8*(2), 75-84. doi: 10.1037//1076-898X.8.2.75

McMillen, J., & Wenzel, M. (2006). Measuring problem gambling: Assessment of three prevalence screens. *International Gambling Studies, 6*(2), 147-174. doi: 10.1080/14459790600927845

Poletti, M., Enrici, I., Bonuccelli, U., & Adenzato, M. (2011). Theory of Mind in Parkinson's disease. *Behavioural Brain Research, 219*(2), 342-350. doi: 10.1016/j.bbr.2011.01.010

Saunders, J. B., Aasland, O. G., Babor, T. F., Fuente, J. R., & Grant, M. (1993). Development of the Alcohol Use Disorders Identification Test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption. *Addiction, 88*(6), 791-804. doi: 10.1111/j.1360-0443.1993.tb02093.x

Stone, V. E., Baron-Cohen, S., & Knight, R. T. (1998). Frontal lobe contributions to theory of mind. *Journal of Cognitive Neuroscience, 10*(5), 640-656. doi: 10.1162/089892998562942

Webster, G. D., DeWall, C. N., Pond, R. S., Deckman, T., Jonason, P. K., Le, B. M., . . . Bator, R. J. (2014). The brief aggression questionnaire: Psychometric and behavioral evidence for an efficient measure of trait aggression. *Aggressive Behavior, 40*(2), 120-139. doi: 10.1002/ab.21507

Webster, G. D., DeWall, C. N., Pond, R. S., Deckman, T., Jonason, P. K., Le, B. M., . . . Bator, R. J. (2015). The brief aggression questionnaire: Structure, validity, reliability, and generalizability. *Journal of Personality Assessment*, 1-12. doi: 10.1080/00223891.2015.1044093

Yu, R.-L., & Wu, R.-M. (2013). Social brain dysfunctions in patients with Parkinson's disease: a review of theory of mind studies. *Translational Neurodegeneration, 2*, 7-7. doi: 10.1186/2047-9158-2-7

Appendix G: Beck Cognitive Insight Scale

Beck Cognitive Insight Scale

	Do not agree at all	Agree slightly	Agree a lot	Agree completely
(1) At times, I have misunderstood other people's attitudes towards me.				
(2) My interpretations of my experiences are definitely right.				
(3) Other people can understand the cause of my unusual experiences better than I can.				
(4) I have jumped to conclusions too fast.				
(5) Some of my experiences that have seemed very real may have been due to my imagination.				
(6) Some of the ideas I was certain were true turned out to be false.				
(7) If something feels right, it means that it is right.				
(8) Even though I feel strongly that I am right, I could be wrong.				
(9) I know better than anyone else what my problems are.				
(10) When people disagree with me,they are generally wrong.				
(11) I cannot trust other people's opinion about my experiences.				
(12) If somebody points out that my beliefs are wrong, I am willing to consider it.				
(13) I can trust my own judgment at all times.				
(14) There is often more than one possible explanation for why people act the way they do.				
(15) My unusual experiences may be due to my being extremely upset or stressed.				

Self Reflectiveness Items 1,3,4,5,6,8,12,14,15

Self Certainty Items 2,7,9,10,11,13

Compostie Score = Self reflectiveness - self certainty

Appendix H: Participant Information Sheet

Curtin University

Participant Information Sheet

Project title: The Measurement and Nature of Impulsivity in Parkinson's Disease

Ethics approval reference: (HR85/2016)

Invitation

You are invited to participate in research examining the current methods used to measure impulsive behaviours in people with Parkinson's disease. Before deciding if you want to take part in this study please read the following information carefully.

Why have I been invited to participate in this research?

You have been invited to take part in this research because you have expressed an interest in participation and have met the inclusion criteria. The decision to participate is completely yours. Should you choose to participate, you are free to withdraw from the research at any time. It is important that you understand what your participation will involve, and why the research is being conducted. The following information should help you to decide whether you wish to take part in this research.

Background

Some research has shown that people with Parkinson's may experience symptoms other than issues with movement. One of these symptoms is a possible increase in impulsive behaviours. Currently, there is no agreed way to measure these impulsive behaviours. Different ways of measuring impulsive behaviours have been used such as using questionnaires and interviews. However, there are some concerns about how effective these methods are.

What are the aims of this study?

We want to test how well the measures for impulsive behaviours work. We want to see if these measures are appropriate for use in people with Parkinson's, and if they properly measure the behaviours they are supposed to.

This research will increase our understanding of the tests used to measure impulsivity in people with Parkinson's, and also our knowledge about impulsivity itself. This will help us to better identify impulsivity problems in people with Parkinson's and subsequently provide treatment to those that need assistance.

Who is involved in this study?

This study is being conducted as part of a PhD research project. Leon Booth is a current PhD student at Curtin University who will be leading the research project. The results of the research will be used towards Leon Booth's PhD project. Dr Andrea Loftus is a supervisor for the present study and current director of ParkC (Parkinson's disease research collaboration). Andrea has extensive experience and expertise in the area of Parkinson's disease. Associate Professor Natalie Gasson will also be supervising this study. Natalie is a registered psychologist and has made significant contributions to research in Parkinson's disease and ParkC.

What will participation involve?

As discussed over the phone this information pack has been sent to you because you have expressed interest in this study. We have made an appointment to carry out some tests in person. Before we meet, we would like you to complete the materials contained in this information pack. It will take about an hour to complete everything in the pack, feel free to spread this out over a few days if you wish. The information pack contains this information sheet, and a map with instructions on how to get to Curtin University and where to park. The information pack also contains a questionnaire booklet for you to complete which will ask about various impulsive behaviours.

As we previously talked about, you also need to arrange for a person that knows you really well to answer some questions. A separate envelope will contain the questionnaires to be completed by the person that you nominate to do this. This envelop is marked on the front "nominated informant information pack". These questionnaires are just different versions of the questionnaires that you have. It is important that you complete these questionnaires individually so that they reflect your own opinions.

Please bring all the contained materials in the information pack to the appointment, including the envelope with the materials completed by person you nominated. A researcher will come to meet you at the car park on your arrival at Curtin University. At the lab you will have the chance to ask any questions you have about the research before testing starts. The appointment will start with a test to measure the motor symptoms of your Parkinson's. Then you will complete three tasks/games on a computer which examine your behaviour. The assessment should not take much longer than an hour. During testing we will be sure to take breaks whenever you like and refreshments will be available.

If you are unsure of anything feel free to discuss this when we meet, or you can contact someone from the research team by emailing/calling them. If you like, you can bring a support person along with you to the appointment. The appointment doesn't require you to discuss your responses to the questionnaires. If you wish to do so, your support person may have to leave momentarily to maintain the confidentiality of your answers.

What are the benefits of participation?

Research into Parkinson's disease depends on the generosity of people who donate their time. Although the research may not directly benefit yourself, it will help to inform future research concerning impulsivity in people with Parkinson's. This will lead to better identification of impulsivity issues in people with Parkinson's, which enables clinicians to more effectively treat and manage problematic impulsive behaviours. The ultimate goal of this research is to benefit people with Parkinson's.

To assist with any costs incurred as a result of taking part in the research you will receive a $10 Coles Myer gift for participating.

Are there any risks involved in participation?

This study should present a minimal risk to you. Every effort will be made to ensure that your experience of participation is enjoyable. In exploring a topic like impulsivity, some of the questions asked may seem personal or strange. You will be asked questions about sensitive

topics such as drug use, gambling, sexual behaviour, and aggression. Some people might feel uncomfortable answering these questions. It is important for you to understand that you only have to tell the researchers information that you are comfortable in revealing. If your responses to any of the questionnaires indicate that you might have an issue with an impulsive behaviour we will contact you. This way we can let you know about the possible issue, and if you like discuss some options to get assistance.

Who will have access to my data?

Only the research team will have access to your data. The research team consists of PhD student Leon Booth and supervisors Dr Andrea Loftus and A/Prof Natalie Gasson. All data/information collected in the study will by anonymous, participant code numbers are used to ensure this. Due to being involved in the data collection process the research team will be able to re-identify participants using the participant code numbers. All publications that result from the research will not contain any information that could be used to identify participants. Data collected will be stored for seven years, as is required by university regulations.

Does this study meet ethical requirements?

The study will be follow the procedures set out in the revised National Statement on Ethical Conduct in Research Involving Humans (June 2007) produced by the National Health and Medical Research Council of Australia. The study has also been reviewed and approved by the Human Research Ethics Committee of Curtin University (HR85/2016).

Do I get to keep a copy of the information sheet and Consent form?

You will be given a copy of the information sheet to keep. If you decide to take part in the research you may request a copy of the signed consent form for your records.

What if I wish to make a complaint?

If you wish to make a complaint about the manner in which this research has been conducted, or have any concerns about the ethical nature of the study, please contact the Human Research Ethics Committee on (08) 92667863 or by emailing hrec@curtin.edu.au. The Manager on Research Integrity can be contacted by calling (08) 9266 7093. Alternatively, you may write to the Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth, WA, 6845. Note that complaints will be kept confidential.

Would you like more information?

If you have any questions about this research, or require more information please feel free to contact us.

You can contact PhD student Leon Booth by emailing leon.booth@postgrad.curtin.edu.au or calling 0426217735

Alternatively if you wish you can contact the supervisory researchers. Dr Andrea Loftus can be contacted by emailing andrea.loftus@curtin.edu.au or calling 08 9266 7279.

Associate Professor Natalie Gasson can be contacted by emailing n.gasson@curtin.edu.au or calling 08 9266 4308.

Information sheet
Version 3
08/04/2016

Appendix I: Nominated Informant Information Sheet

Curtin University

Nominated Informant Information Sheet

Project title: The Measurement and Nature of Impulsivity in Parkinson's disease

Ethics approval reference: (HR85/2016)

Invitation

You are invited to participate in research examining the current methods used to measure impulsive behaviours in people with Parkinson's disease. Before deciding if you want to take part in this study please read the following information carefully.

Why have I been invited to participate in this research?

You have been invited to take part because a potential participant in our research has nominated you as an informant. This means that the potential participant has identified you as a person that knows them well. The research project requires a nominated informant that knows the person with Parkinson's disease to assist in providing data. The decision to participate is completely yours. Should you choose to participate, you are free to withdraw from the research at any time. It is important that you understand what your participation will involve, and why the research is being conducted. The following information should help you to decide whether you wish to take part in this research.

Background

Some research has shown that people with Parkinson's may experience symptoms other than issues with movement. One of these symptoms is a possible increase in impulsive behaviours. Currently, there is no agreed way to measure these impulsive behaviours. Different ways of measuring impulsive behaviours have been used such as using questionnaires and interviews. However, there are some concerns about how effective these methods are. One proposed method to better measure these impulsive behaviours is to ask friends and family of the person with Parkinson's (nominated informants). Research has suggested that nominated informants can provide useful information as to whether someone with Parkinson's displays these sorts of behaviours.

What are the aims of this study?

We want to test how well the measures for impulsive behaviours work. We want to see if these measures are appropriate for use in Parkinson's, and if they properly measure the behaviours they are supposed to.

This research will increase our understanding of the tests used to measure impulsivity in Parkinson's, and also our knowledge about impulsivity itself. This will help us to better identify impulsivity problems in Parkinson's and subsequently provide treatment to people that need assistance.

Who is the chief researcher of this study?

This study is being conducted as part of a PhD research project. Leon Booth is a current PhD student at Curtin University who will be leading the research project. The results of the

research will be used towards Leon Booth's PhD project. Dr Andrea Loftus is a supervisor for the present study and current director of ParkC (Parkinson's disease research collaboration). Andrea has extensive experience and expertise in the area of Parkinson's disease. Associate Professor Natalie Gasson will also be supervising this study. Natalie is a registered psychologist and has made significant contributions to research in Parkinson's disease and ParkC.

What will participation involve?

The information pack that our participant has provided to you should contain an information sheet (this document), consent form, envelope, and a questionnaire booklet for you to complete. The questionnaires are just different versions of the questionnaires that the participant will also complete. If you choose to participate as the nominated informant you will be required to complete the enclosed consent form followed by the three questionnaires (ensure you complete the consent form first). When you fill out the questionnaires you are completing them with respect to the participant with Parkinson's. Your responses should be about the person with Parkinson's and reflect your judgment of their behaviours.

After completing the consent form and questionnaires you should put them into the envelope provided in your information pack and seal them. This helps to ensure that your responses remain confidential. This data will be linked to the participant's data and used in the research project. Your own responses will be matched to the participant responses to see how they compare. This will allow the research to determine whether using nominated informants to measure impulsive behaviours can benefit both research and clinical practice. Therefore, it is important that you complete these questionnaires individually so that they reflect your own opinions.

What are the benefits of participation?

Research into people with Parkinson's disease depends on the generosity of people who donate their time. Although the research may not directly benefit yourself, it will help to inform future research concerning impulsivity in Parkinson's. This will lead to better identification of impulsivity issues in people with Parkinson's, which enables clinicians to more effectively treat and manage problematic impulsive behaviours. The ultimate goal of this research is to benefit people with Parkinson's and their peers.

Are there any risks involved in participation?

This study should present a minimal risk to you. Every effort will be made to ensure that your experience of participation is enjoyable. In exploring a topic like impulsivity, some of the questions asked may seem personal or strange. It is important for you to understand that you only have to tell the researchers information that you are comfortable in revealing. Any information that you provide regarding the participant will not be disclosed to the participant.

Who will have access to my data?

Only the research team will have access to your data. The research team consists of PhD student Leon Booth and supervisors Dr Andrea Loftus and A/Prof Natalie Gasson. All data/information collected in the study will by anonymous, participant code numbers are used to ensure this. Due to being involved in the data collection process the research team will be

able to re-identify participants using the participant code numbers. All publications that result from the research will not contain any information that could be used to identify participants. Data collected will be stored for seven years, as is required by university regulations.

Does this study meet ethical requirements?

The study will be follow the procedures set out in the revised National Statement on Ethical Conduct in Research Involving Humans (June 2007) produced by the National Health and Medical Research Council of Australia. The study has also been reviewed and approved by the Human Research Ethics Committee of Curtin University (HR85/2016).

Do I get to keep a copy of the information sheet and Consent form?

You will be given a copy of the information sheet to keep. If you decide to take part in the research you may request a copy of the signed consent form for your records.

What if I wish to make a complaint?

If you wish to make a complaint about the manner in which this research has been conducted, or have any concerns about the ethical nature of the study, please contact the Human Research Ethics Committee on (08) 92667863 or by emailing hrec@curtin.edu.au. The Manager on Research Integrity can be contacted by calling (08) 9266 7093. Alternatively, you may write to the Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth, WA, 6845. Note that complaints will be kept confidential.

Would you like more information?

If you have any questions about this research, or require more information please feel free to contact us.

You can contact PhD student Leon Booth by emailing leon.booth@postgrad.curtin.edu.au or calling 0426217735

Alternatively if you wish you can contact the supervisory researchers. Dr Andrea Loftus can be contacted by emailing andrea.loftus@curtin.edu.au or calling 08 9266 7279.

Associate Professor Natalie Gasson can be contacted by emailing n.gasson@curtin.edu.au or calling 08 9266 4308.

Appendix J: Nominated Informant Consent Form

Curtin University

Nominated Informant Consent Form

Project title: The Measurement and Nature of Impulsivity in Parkinson's

Please tick the boxes

☐ 1. I have read and understood the 'Information Sheet' for this study.

☐ 2. I understand the nature and purpose of this study and that the likelihood of risk to me personally is low. However, issues concerning impulsivity will be explored which have the potential be uncomfortable.

☐ 3. Any questions I have asked have been answered to my satisfaction.

☐ 4. I understand that this research involves a number of paper based questionnaires.

☐ 5. I understand that all research data will be securely stored at Curtin University stored on password protected computers and locked cabinets. I understand that data will be stored for a minimum of seven years following the study end date before being destroyed.

☐ 6. I agree that research data for the study may be published and that I will not be identified as a participant.

☐ 7. I understand that my identity will be kept confidential and that any information I supply to the researchers will be used only for the purposes of this research.

☐ 8. I understand that participation in this study is voluntary.

☐ 9. I agree to participate in this research and understand that I may withdraw at any time without giving a reason, and without my medical care or legal rights being affected. I also understand that if I so wish, I may request that any personal data gathered be withdrawn from the research.

☐ 10. I understand that I can request a signed copy of this consent form.

Name of Participant (nominated informant)_____

Signature of

Participant_____Date_____

For the Investigator

I have explained this project and the implications of participation to this volunteer and believe that the consent is informed and that he/she understands the implications of participation.

Name of Researcher_____

Signature of

Researcher_____Date_____

Curtin University Human Research Ethics Committee (HREC) has approved this study (HR85/2016). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08)9266 7093 or email hrec@curtin.edu.au.

Consent form
Version 3
08/04/2016

Appendix K: Nominated Informant Questionnaire Booklet

Questionnaire Booklet for Nominated Informant

Please read the information sheet and sign the consent form before completing this questionnaire booklet.

This booklet contains a few questionnaires that will ask you about various behaviours that the participant with Parkinson's may or may not have. We recommend that you complete the booklet on your own as it should reflect your interpretation of their behaviours. Take your time with this booklet, it doesn't have to be finished in one go. You can take regular breaks throughout this questionnaire.

When you have completed all the documents please place them in the provided envelope and return them to the participant. If you prefer, you can use the replied paid envelope and post the documents to Curtin. If you are unsure about anything or have any questions, feel free to contact us.

Remember you are answering the questions about the person that you know with Parkinson's. You are answering about their thoughts and behaviours, not your own.

Thank you,

Leon Booth

Email: leon.booth@postgrad.curtin.edu.au

Phone: 042 621 7735

Behavioural Inhibition System/Behavioural Activation System Scale

Each item of this questionnaire is a statement that a person may either agree with or disagree with. For each item, indicate how much you agree or disagree with what the item says in terms of **how it describes the person with Parkinson's**. Please respond to all the items; do not leave any blank. Choose only one response to each statement. Please be as accurate and honest as you can be. Respond to each item as if it were the only item. That is, don't worry about being "consistent" in your responses.

Question	1 Very true for them	2 Somewhat true for them	3 Somewhat false for them	4 Very false for them
1. A person's family is the most important thing in life				
2. Even if something bad is about to happen to me, I rarely experience fear or nervousness				
3. I go out of my way to get things I want				
4. When I'm doing well at something I love to keep at it				
5. I'm always willing to try something new if I think it will be fun				
6. How I dress is important to me				
7. When I get something I want, I feel excited and energized				
8. Criticism or scolding hurts me quite a bit				
9. When I want something I usually go all-out to get it				
10. I will often do things for no other reason than that they might be fun				
11. It's hard for me to find the time to do things such as get a haircut				

Question	1 Very true for them	2 Somewhat true for them	3 Somewhat false for them	4 Very false for them
12. If I see a chance to get something I want I move on it right away				
13. I feel pretty worried or upset when I think or know somebody is angry at me				
14. When I see an opportunity for something I like I get excited right away				
15. I often act on the spur of the moment				
16. If I think something unpleasant is going to happen I usually get pretty "worked up"				
17. I often wonder why people act the way they do				
18. When good things happen to me, it affects me strongly				
19. I feel worried when I think I have done poorly at something important				
20. I crave excitement and new sensations.				
21. When I go after something I use a "no holds barred" approach				
22. I have very few fears compared to my friends				
23. It would excite me to win a contest				
24. I worry about making mistakes.				

Instruction Sheet

Please complete the following 2 pages thinking about the persons behaviours in the past 4 weeks.

Description of Behaviours

This is a description of the kinds of behaviours this questionnaire refers to.

Gambling includes casinos, internet gambling, lotteries, scratch tickets, betting, or slot or poker machines.

Sex includes making sexual demands on others, promiscuity, prostitution, change in sexual orientation, masturbation, internet or telephone sexual activities, or pornography.

Buying includes too much of the same thing or things that you don't need or use.

Eating includes eating larger amounts or different types of food than in the past, more rapidly than normal, until feeling uncomfortably full, or when not hungry.

Hobbyism includes specific tasks, hobbies or other organized activities, such as writing, painting, gardening, repairing or dismantling things, collecting, computer use, working on projects, etc.

Punding includes repeating certain simple motor activities, such as cleaning, tidying, handling, examining, sorting, ordering, collecting, hoarding, or arranging objects, etc.

Medication Use includes consistently taking too much of your Parkinson's medications, or increasing on your own, without medical advice, your overall intake of Parkinson's medications.

Frequency of Behaviours

You will be asked to indicate the frequency of some behaviours. The frequencies are described as:

Never (0) = not at all

Rarely (1) = infrequently or 1 day/week

Sometimes (2) = at times or 2-3 days/week

Often (3) = most of the time or 4-5 days/week

Very often (4) = nearly always or 6-7 days/week

Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease - Rating Scale

(QUIP-RS)

Answer about the persons behaviours in the past 4 weeks.

1. How much do they think about the following behaviors (such as having trouble keeping thoughts out of your mind or feeling guilty)? Please circle your response

Gambling?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Sex?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Buying?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Eating?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Performing tasks or hobbies?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Repeating simple activities?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Taking your PD medications?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)

2. Do they have urges or desires for the following behaviors that you feel are excessive or cause them distress (including becoming restless or irritable when unable to participate in them)?

Gambling?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Sex?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Buying?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Eating?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Performing tasks or hobbies?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Repeating simple activities?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Taking your PD medications?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)

Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease - Rating Scale

(QUIP-RS)

1. Do they have difficulty controlling the following behaviors (such as increasing them over time, or having trouble cutting down or stopping them)?

Gambling?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Sex?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Buying?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Eating?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Performing tasks or hobbies?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Repeating simple activities?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Taking your PD medications?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)

2. Do they engage in activities specifically to continue the following behaviors (such as hiding what they are doing, lying, hoarding things, borrowing from others, accumulating debt, stealing, or being involved in illegal acts)?

Gambling?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Sex?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Buying?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Eating?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Performing tasks or hobbies?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Repeating simple activities?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)
Taking your PD medications?	Never(0)	Rarely(1)	Sometimes(2)	Often(3)	Very often(4)

Screening for Risky Behaviours Battery

The following questionnaire will ask about various behaviours. Please answer the questions as honestly as you can. Remember, you are answering the questions about the person that you know with Parkinson's.

Alcohol Consumption:
Please tick the box that best describes the person with Parkinson's.

Questions	0	1	2	3	4
1. How often do they have a drink containing alcohol?	Never	Monthly or less	2-4 times a month	2-3 times a week	4 or more times a week
2. How many drinks containing alcohol do they have on a typical day when they are drinking?	1 or 2	3 or 4	5 or 6	7 or 9	10 or more
3. How often do they have six or more drinks on one occasion?	Never	Less than Monthly	Monthly	Weekly	Daily or almost Daily

Tobacco Consumption:
Please tick the box that best describes the person with Parkinson's. If they do not smoke just tick the "N/A" box.

Questions	0	1	2	3	4
1. How soon after you wake up do they smoke their first cigarette?	N/A	After 60 Minutes	31-60 minutes	6-30 minutes	Within 5 minutes
2. How many cigarettes a day do they smoke?	0	10 or less	11-20	21-30	31 or more

Drug Consumption:
Please indicate which (if any) of the following drug classes you know they have tried **over the last 12 months** by ticking the box next to the drug in question. If they have not taken any of these drugs tick the box at the bottom.

Drug	Tick this box
Marijuana (weed, cannabis)	
Stimulants (methamphetamine, ice, etc.)	
Cocaine	
Hallucinogens, (LSD, magic mushrooms)	
Opiates (heroin)	
Sedatives (benzodiazepines, valium)	
They have not taken any of these drugs over the last 12 months	

Gambling:
Please indicate which of the following types of gambling the person with Parkinson's has **done in the last 12** months. For each type mark one answer.

Please tick to answer each statement	Not at all	Less than once a week	Once a week or more
Played cards for money			
Bet on horses, dogs, or other animals			
Went to casinos (legal or otherwise)			
Played the numbers or bet on lotteries			
Played bingo			
Played the stock and/or commodities market			
Played slot machines, poker machines, or other gambling machines			
Bowled, shot pool, played golf, or some other game of skill for money			
Played pull tabs or "paper" games other than lotteries			
Some form of gambling not listed above (please specify) _____			

Violence/Aggression: Using this 5 point scale, indicate how uncharacteristic or characteristic each of the following statements is in **describing the person with Parkinson's** (please tick the boxes).

Questions	Extremely uncharacteristic of them	Somewhat uncharacteristic of them	Neither uncharacteristic nor characteristic	Somewhat characteristic of them	Extremely characteristic of them
Given enough provocation, I may hit another person					
If I have to resort to violence to protect my rights, I will					
There are people who pushed me so far that we came to blows					
I tell my friends openly when I disagree with them					
When people annoy me, I may tell them what I think of them					
My friends say that I'm somewhat argumentative					
I am an even-tempered person					
Sometimes I fly off the handle for no good reason					
I have trouble controlling my temper					
Other people always seem to get the breaks					
I sometimes feel that people are laughing at me behind my back					
When people are especially nice, I wonder what they want					

General Behaviours:
Over the last 12 months have they engaged in any of the following behaviours? Please tick the box that best applies.

Questions	0	1	2	3	4
	Never	Rarely	Sometimes	Most of the time	Always
Used any illicit drug					
Used prescription medication without having a prescription					
Gambled for real money					
Stolen anything					
Been in a physical fight					
Ridden in a car without wearing a seatbelt					
Ridden a bicycle or motor cycle without a helmet					
Been in a car when the driver has been under the influence of alcohol					
Driven a car under the influence of alcohol					
Use the phone whist driving (calling, texting, emailing, etc.)					

Socially inappropriate comments/remarks:
Over the Last 12 months have they done any of the following? Please tick the box that best applies.

Questions	0	1	2	3	4
	Never	Rarely	Sometimes	Most of the time	Always
Made an inappropriate remark or comment in conversation.					
Made a comment in a conversation that you have later regretted.					
Said something that has offended other people.					
Said something that has made other people around you upset.					
Had someone mention that something you have said is inappropriate					

If there is anything else you would like us to know about your experience of impulsive behaviours, please use the space below.

Appendix L: Participant Consent Form

Curtin University

Consent Form

Project title: The Measurement and Nature of Impulsivity in Parkinson's

Please Tick Box

☐ 1. I have read and understood the 'Information Sheet' for this study.

☐ 2. I understand the nature and purpose of this study and that the likelihood of risk to me personally is low. However, issues concerning impulsivity will be explored which have the potential be uncomfortable.

☐ 3. Any questions I have asked have been answered to my satisfaction.

☐ 4. I understand that this research involves a number of computer and paper based tasks.

☐ 5. I understand that all research data will be securely stored at Curtin University stored on password protected computers and locked cabinets. I understand that data will be stored for a minimum of seven years following the study end date before being destroyed.

☐ 6. I agree that research data for the study may be published and that I will not be identified as a participant.

☐ 7. I understand that my identity will be kept confidential and that any information I supply to the researchers will be used only for the purposes of this research.

☐ 8. I understand that participation in this study is voluntary.

☐ 9. I agree to participate in this research and understand that I may withdraw at any time without giving a reason, and without my medical care or legal rights being affected. I also understand that if I so wish, I may request that any personal data gathered be withdrawn from the research.

☐ 10. I understand that I can request a signed copy of this consent form.

☐ 11. I understand that I will receive a $10 Coles Myer gift card which is intended to contribute towards costs incurred as a result of participation.

Name of Participant_____

Signature of

Participant_____Date_____

For the Investigator

I have explained this project and the implications of participation to this volunteer and believe that the consent is informed and that he/she understands the implications of participation.

Name of Researcher_____

Signature of

Researcher_____Date_____

Curtin University Human Research Ethics Committee (HREC) has approved this study (HR85/2016). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08)9266 7093 or email hrec@curtin.edu.au.

Consent form
Version 3
08/04/2016

Appendix M: Debriefing Information Sheet

Debriefing Information Sheet

Project title: The Measurement and Nature of Impulsivity in Parkinson's

Thank you for participating in this research. It is because of generous people like you that research like this can take place. As participation in this research involves the discussion of sensitive issues, we would like to provide you with the following information.

This sheet lists a number of services that can assist with the sensitive issues explored in this study. If you would like to talk with someone about the issues explored in this study, we encourage you to talk with your neurologist, general practitioner, geriatrician, or with one of the specialist nurses at Parkinson's Western Australia. You can also contact the services listed below if you want to seek help for another issue that is concerning you about your Parkinson's. Please feel free to contact the researchers involved in this study if you have any further questions about who you could talk to.

We want to stress that this information sheet has not been provided to you because we think you have an issue with a particular behaviour. As this is a research project, we are not able to make any diagnoses about your behaviours. This sheet is to provide you with some options just in case you think that you are having problems or need help with an issue examined in this study.

You can contact Mr Leon Booth by emailing leon.booth@postgrad.curtin.edu.au or by calling 0426217735. Alternatively, you can contact the supervising researchers. Dr Andrea Loftus can be contacted by emailing andrea.loftus@curtin.edu.au or calling 08 9266 7279. Associate Professor Natalie Gasson (Registered Psychologist) can be contacted by emailing n.gasson@curtin.edu.au or calling 08 9266 4308.

Who can you talk to about some of the problem behaviours you may be experiencing?

Parkinson's Western Australia
Parkinson's Western Australia aims to encourage, develop, and implement programs for the cure, treatment, and care of people with Parkinson's. They provide support services including a specialised nurse service, support groups, and seminars.
Phone (specialist nurses office): 08 9346 7371
Phone: 08 9346 7373
Email: info@parkinsonswa.org.au
Website www.parkinsonswa.org.au

Drink Wise Australia
Drink Wise Australia provides information on the various impacts of alcohol consumption. The website also provides advice on reducing alcohol consumption.
Phone: 03 9682 8641
Email: info@drinkwise.org.au
Website: www.drinkwise.org.au

Alcoholics Anonymous
Alcoholics Anonymous fosters support groups for people that want to stop consuming alcohol. The meetings take place at local community centres or online. A phone helpline is also available.
Phone: 1300 222 222
Website www.aa.org.au

Quitline
Quitline provides resources to assist people that want to quit smoking (tobacco). The service provides a helpline, applications, and information to help people quit smoking.
Phone: 137848
Website: www.quitnow.gov.au/internet/quitnow/publishing.nsf/Content/home

24 Hour Alcohol and Drug Support Lines
A government funded 24/7 helpline for people concerned about their own or someone else's alcohol/drug use. The service provides support, counselling, information, and referral services.
Phone: 08 9442 5000
Country callers: 1800 198 024
Email: alcoholdrugsupport@mhc.wa.gov.au
Website: www.dao.health.wa.gov.au/Gettinghelp/24HourAlcoholAndDrugSupportLines.aspx

National Cannabis Prevention and Information Centre
The National Cannabis Prevention and Information Centre provides information on cannabis and how it affects people. The centre also has an application to assist people in reducing their cannabis consumption. A helpline is also available.
Phone: 1800 30 40 50
Website: www.ncpic.org.au

Gambling Help WA
Gambling Help WA is a free face to face counselling service for people affected by problematic gambling. The service assists the person with a gambling issue and also their family and friends. An appointment can be made by calling the provided phone number.
Phone: 08 9325 6644

Problem Gambling Helpline
The problem gambling helpline is a 27/7 service which helps people to overcome gambling related problems. The helpline offers counselling and referral services.
Phone: 1800 858 858

Domestic Violence Helplines
The department for child protection and family support provides 24/7 helplines to assist those in aggressive or violent households.
Crisis Care Helpline
Phone: (08) 9223 1111 or free call 1800 199 008
Men's Domestic Violence Helpline
Phone: (08) 9223 1199 or free call 1800 000 599
Women's Domestic Violence Helpline (including for referral to a women's refuge)
Phone: (08) 9223 1188 or free call 1800 007 339

Lifeline
Life line is a crisis support and suicide prevention service. They provide help for a number of different issues including, substance abuse, depression, gambling, and family violence. Lifeline have a 24/7 helpline that can be called when a person needs immediate help. The website also provide information on dealing with various issues.
Phone 13 11 14
Website: www.lifeline.org.au/Home

Appendix N: Ethics Approval

MEMORANDUM

Curtin University

To:	Dr Andrea Loftus School of Psychology and Speech Pathology
CC:	Leon Booth
From	Professor Peter O'Leary, Chair HREC
Subject	Ethics approval Approval number: HR85/2016
Date	05-May-16

Office of Research and Development
Human Research Ethics Office

TELEPHONE 9266 2784
FACSIMILE 9266 3793
EMAIL hrec@curtin.edu.au

Thank you for your application submitted to the Human Research Ethics Office for the project: 6584

The Measurement and Nature of Impulsivity in Parkinson's Disease

Your application was reviewed by Human Research Ethics Committee at Curtin University at their meeting on the 05/04/2016

Thankyou for providing the additional information requested by the Human Research Ethics Committee. The information you provided was satisfactory and your proposal is now approved.

Please note the following conditions of approval:

1. Approval is granted for a period of four years fror **05-May-16** to **05-May-20**
2. Research must be conducted as stated in the approved protocol.
3. Any amendments to the approved protocol must be approved by the Ethics Office.
4. An annual progress report must be submitted to the Ethics Office annually, on the anniversary of approval.
5. All adverse events must be reported to the Ethics Office.
6. A completion report must be submitted to the Ethics Office on completion of the project.
7. Data must be stored in accordance with WAUSDA and Curtin University policy.
8. The Ethics Office may conduct a randomly identified audit of a proportion of research projects approved by the HREC.

Should you have any queries about the consideration of your project please contact the Ethics Support Officer for your faculty, or the Ethics Office at hrec@curtin.edu.au or on 9266 2784. All human research ethics forms and guidelines are available on the ethics website.

Yours s[redacted]

Profess[redacted]
Chair, Human Research Ethics Committee