The Impact of Personality on Actual and Self-reported Memory in Parkinson's Disease.

Dissertation submitted by

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Declaration

I declare that this honours dissertation is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

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8th November 2013

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Abstract

Parkinson's disease is a degenerative neurological disorder associated with impairments in memory and spatial abilities. This study examined the impact of Memory Self-Efficacy (MSE) on spatial working memory performance in people with Parkinson's disease (PD) over a two year period. This study also examined the moderating effect of openness to experience and neuroticism on this relationship. This longitudinal study consisted of 64 males and 33 females ($N = 97$) aged between 37 and 85 ($M = 63.99$, $SD = 9.02$) at Time 1, with participants repeating the study two years later. Significant relationships were found between MSE and openness to experience ($r = .289$) and MSE and neuroticism ($r = -.445$). Following two hierarchical multiple regressions, MSE did not significantly predict spatial working memory. In addition, openness to experience and neuroticism did not significantly moderate this relationship. Future research should examine the nature and direction of the MSE and spatial working memory relationship. This may provide an understanding of the appropriate stage at which to target interventions, and may assist in improving social and cognitive engagement and quality of life in people with PD.

Keywords: Memory self-efficacy, spatial working memory, openness to experience, neuroticism, Parkinson's disease.

Parkinson's disease (PD) is an idiopathic, degenerative neurological disorder, second only to dementia in prevalence (Access Economics, 2011). Although the onset of symptoms varies between individuals with PD, both motor and non-motor symptoms are characteristic of PD. Motor symptoms are the most commonly recognised symptoms for diagnosis and are the main focus of PD research (Schapira et al., 2009). However, non-motor symptoms, such as cognitive impairment and neuropsychiatric symptoms often precede motor symptoms and become more prominent as PD severity increases (Schapira et al., 2009). Memory is reported as the most frequently impaired cognitive domain in PD, with specific deficits in working memory (Aarsland et al., 2010). These deficits in working memory are associated with poor quality of life and disengagement from everyday activities (Aarsland et al., 2010). It is important for PD research to investigate the impact of memory deficits, as they are a leading cause of hospitalisation and institutionalisation in people with PD (Ceravolo, Rossi, Kiferle & Bonuccelli, 2010).

Working memory (WM) has been described as a limited storage capacity system that temporarily stores and manipulates information and is necessary to complete cognitive tasks (Baddeley, 2000). Baddeley's model of working memory proposed that the visuo-spatial sketchpad is a crucial element of working memory, as it is necessary for performing cognitive tasks relating to non-verbal memory. The visuo-spatial sketchpad is also responsible for storing and manipulating both visual and spatial information (Baddeley, 2000; McAfoose & Baune, 2009). A meta-analysis by Siegert, Weatherall, Taylor and Abernethy (2008) reported that visuo-spatial working memory was impaired in participants with PD, compared to non-PD participants. However, research into WM impairments identified individual differences in processes underlying visual and spatial working memory, suggesting that while one subcomponent may be impaired, other subcomponents continues to function (McKinlay, 2010; Pillon et al., 1998; Siegert et al., 2008). This is consistent with PD research suggesting that spatial working memory is more impaired in PD, compared to visual and verbal working memory (Aarsland et al., Johnson & Galvin, 2011). Research has investigated if the differences between visual, verbal, and spatial working memory impairment may be due to confounding variables, such as task difficulty and dopamine medication (Marini, Ramat, Ginestroni & Paganini, 2003; Pillon et al., 1998; Possin, Filoteo, Song & Salmon, 2008; Siegert et al., 2008). It was found that visual and verbal working memory impairment were impacted by task difficulty and dopamine medication, but spatial working memory remained impaired. This provides evidence of

specific impaired encoding processes of spatial information in PD (Marini et al., 2003; Possin et al., 2008; Scheife, Schumock, Burstein, Gottwald & Luer, 2000).

Healthy ageing research has established a relationship between perceived memory functioning and actual memory abilities (Valentijn et al., 2006). Memory decline is a part of ageing, with older individuals typically attributing faulty performance to a decline in memory capacity and not to knowledge error (McDougall, 2009; Valentijn et al., 2006). This performance reinforces a person's feelings and beliefs about their ability to use memory effectively (memory self-efficacy; MSE), and can both hinder and improve cognitive performance (Bandura, 1989). Self-efficacy operates in a cycle, whereby perceived failures reinforce future inefficacy and perceived triumphs reinforce strong self-efficacy (Bandura, 1989). This is supported in longitudinal research suggesting that changes in MSE are mirrored by changes in memory performance (Valentijn et al., 2006). The relationship between MSE and memory performance is also moderated by cognitive impairment in ageing populations. Research suggests that those who are more aware of cognitive deficits are less likely to participate in memory activities, with errors reinforcing poor MSE (Roberts, Clare & Woods, 2009). The relationship between MSE and working memory also indicates the impact of cognitive impairment on MSE, with those who reported lower MSE improving less on working memory tasks compared to those who reported higher MSE (Valentijn et al., 2006). Much of the research into the MSE and WM relationship has focused on verbal working memory in cognitively impaired populations (McDougall & Pfeifer, 2012). Studies of spatial working memory and MSE have been conducted in healthy, younger adults, who are unlikely to identify themselves as having any changes in memory performance (Beaudoin & Desrichard, 2011). A longitudinal study by Seeman, McAvay, Merrill, Albert & Rodin (1996) suggested that stronger MSE predicted better levels of performance in some cognitive domains. Although no significant relationship was found for spatial abilities, the non-significance may be due to the selection of older adults with no cognitive impairment (Seeman et al., 1996). To support the findings from cross-sectional studies investigating MSE and performance on memory tasks further longitudinal studies are required (Seeman et al., 1996). As memory and spatial abilities are most commonly impaired in PD (Aarsland et al., 2010), it is important to further investigate the relationship between MSE and spatial working memory in a PD population.

Consistent with research on the relationship between MSE and verbal working memory, a relationship between MSE and spatial working memory may be influenced by individual differences (Beaudoin & Desrichard, 2011). Research suggests that age, gender

and depression impact upon the strength of the MSE and working memory relationship in cognitively impaired populations (Beaudoin & Desrichard, 2011). However, the results are inconsistent, and other individual differences, such as personality, should be considered (Beaudoin & Desrichard, 2011; Comijs, Deeg, Dik, Twisk & Jonker, 2002; Roberts et al., 2009).

The five factor model of personality is often used in health and memory research (McCrae & Costa, 1992). Although all five personality traits have a small, but significant, relationship with cognition, the strongest relationships have been found for openness to experience and neuroticism (William, Suchy & Kraybill, 2010). People with higher openness demonstrate better cognitive, memory, and spatial abilities. In contrast, those who score highly for neuroticism do not perform well in WM tasks (Williams et al., 2010). Research into healthy ageing and personality suggests that age-related changes may lead certain personality characteristics to influence cognition more than others. Increased age is often associated with lower levels of neuroticism and openness and with higher levels of conscientiousness and agreeableness (Soubelet & Salthouse, 2011; Wortman, Lucas & Donnellan, 2012).

Although lower levels of neuroticism and openness are associated with increased age, this may not be representative of the ageing population who experience problems with their memory. The impact of neuroticism on cognitive ability is unclear in ageing research, despite higher levels of neuroticism in older adults being associated with mild cognitive impairment and poor decision making (Jelicic et al., 2003; William et al., 2010). Research into the relationship between openness and cognitive functioning suggests that the two have a unique relationship that may serve to prevent cognitive decline (Williams et al., 2010; Booth, Schinka, Brown & Borenstein, 2006). This is supported in MSE and personality research which suggests that certain levels of openness and neuroticism are associated with increased memory complaints in older adults (Comijs et al., 2002). High neuroticism is associated with poor working memory performance, and disengagement from social and cognitive activities. In contrast, individuals high in openness are more likely to have positive memory beliefs and a willingness to adopt strategies to improve perceived deficits (Soubelet & Salthouse, 2011; Williams et al., 2010).

The relationship between MSE, spatial working memory and personality in PD is unclear (Demetriou, Kyriakides & Avraamidou, 2003). Many studies have alluded to personality as a potential moderator of the MSE and WM relationship (Beaudoin & Desrichard, 2011; Possin et al., 2008). Cavanaugh and Green (1990) suggested that the

relationship between MSE and memory performance was 'crooked' and could not be evaluated without considering personality as a potential moderator. This is because personality encompasses aspects of self-efficacy and memory performance (Cavanaugh & Green, 1990). A longitudinal study by Valentijn et al. (2006) suggested that the combination of MSE and personality has a stronger impact on memory performance over time, compared to individual contributions. This is due to the close relationship between MSE and personality. By investigating these relationships in a PD population, an understanding of the impact of personality may assist in improving spatial working memory performance. The development of personality specific interventions may combine programs aimed at improving MSE and engagement in social and cognitive tasks (Booth et al., 2006). This research will explore the relationship between MSE and spatial working memory in PD, and whether this relationship is moderated by openness and neuroticism. The primary hypothesis of the study is that after controlling for age and gender, MSE at Time 1 will significantly predict spatial working memory at Time 2 (Figure 1). The secondary hypotheses are (i) openness to experience will significantly moderate the relationship between MSE and spatial working memory in PD (Figure 1a), and (ii) neuroticism will significantly moderate the relationship between MSE and spatial working memory in PD (Figure 1b).

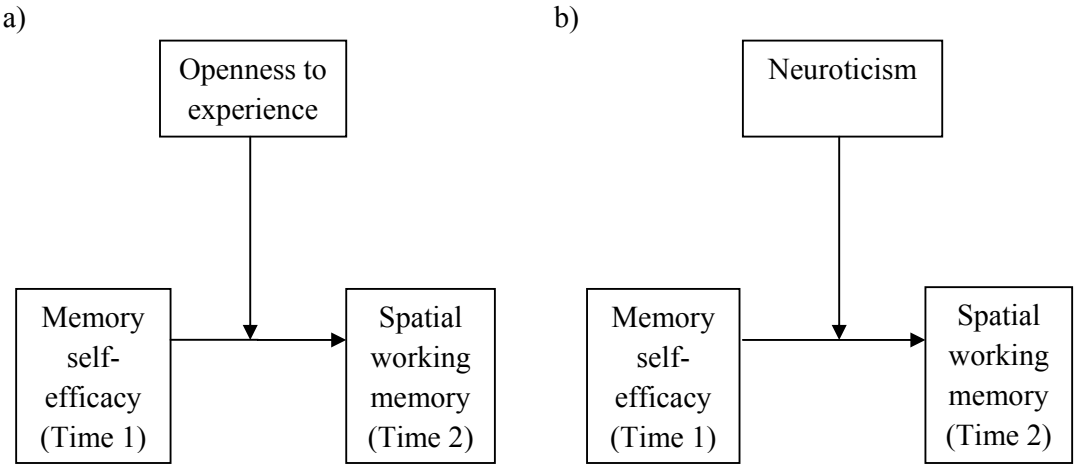

Figure 1. The moderator model of the memory self-efficacy and spatial working memory relationship with a) openness to experience as a potential moderator, and b) neuroticism as a potential moderator.

Method

Research Design

This study emerged from the "Cognitive and Motor Heterogeneity in Idiopathic Parkinson's Disease" longitudinal research project that is being conducted by the Parkinson's Centre (ParkC), at Edith Cowan University. A longitudinal design was used as it is a more powerful design for a causal model compared to a cross-sectional design (Field & Hole, 2003). MSE at Time 1 was the predictor and spatial working memory at Time 2 as the criterion. Openness to experience and neuroticism were the moderator variables. Age and gender were included as control variables.

Participants. This study had ethics approval through Edith Cowan University (Project 2736). A convenience sample of self-referred people with diagnosed idiopathic PD, were recruited through local and PWA advertising (Time 1: *N*= 247, Time 2: *N*= 116). Inclusion in the study was based on a PD diagnosis according to the UK Brain Bank Clinical Diagnostic Criteria (Hughes, Daniel, Kilford & Lees, 1992). Eleven participants were excluded due to a misdiagnosis of PD. Eleven participants were excluded for scoring <24 on the Mini Mental State Exam at Time 1. Seven participants were excluded due to stroke or loss of consciousness. One hundred and fourteen participants were removed as they had not yet completed the two year follow up period. Six participants were excluded for missing data on at least one full measure. One participant scored >3.29 standard deviations from the mean on the MMQ-Ability subscale and was excluded (Tabachnick & Fidell, 2013). The final sample consisted of 97 participants (M = 63.99, SD = 9.02), 64 Males (66%) and 33 Females (34%). To achieve a small to medium effect size at .05 alpha, a priori power analysis using G*Power recommended a minimum of 90 participants, so this sample size was considered adequate (Faul, Erdfelder, Lang & Buchner, 2007).

Measures

An information pack, including a cover letter, information sheet, appointment slip, a map and 11 self-report surveys were posted to participants prior to attending testing. Three of the self-reported surveys are included in this study. The participant assessment includes a consent form, motor assessment and 10 cognitive assessments. Only one cognitive assessment was included in this study.

Mini Mental State Exam (MMSE). This questionnaire is a reliable cognitive screening measure (r=.88-.98) that is able to detect global cognitive impairment (Folstein et al., 1975). Scores <24 on the MMSE indicated cognitive impairment, with all participants scoring <24 excluded from the study.

Cognitive and Motor Heterogeneity in Idiopathic Parkinson's Medical History and Demographic Questionnaire. This questionnaire provided information regarding demographics, emergency contact information, medication history and medical history. Age and gender were collected from this measure and used as control variables.

Meta-Memory Questionnaire (MMQ). The MMQ, developed by Troyer and Rich (2002), consists of three subscales designed to measure self-reported memory contentment, ability and strategy. The contentment subscale measures a person's feelings towards their memory, and is often used in MSE research. However, this research will focus on the ability subscale. The ability subscale is a self-evaluation of a person's memory ability (Troyer & Rich, 2002). This perception of ability was used as the measure of MSE. The ability subscale consists of 20 questions, and was scored on a 5-point Likert scale. The ability subscale measured perceived memory mistakes, with statements such as, "Forget to pay a bill on time" with responses ranging from "All the time" to "Never" (0-4). Higher scores on the ability subscale (total score of 80), indicated less perceived memory mistakes, while lower scores indicated higher memory mistakes. Previous research has found the ability subscale to be a reliable (α=.93, r=.86) measure of perceived memory mistakes (Troyer & Rich, 2002). Content validity was established among 12 memory experts, with 70% overall agreement. Convergent validity was satisfactory when compared to the Memory Functioning Questionnaire and the Meta-Memory in Adulthood Questionnaire (Troyer & Rich, 2002). Consistent with previous research, the MMQ-Ability subscale was found to be reliable (α=.92) in this study.

Big Five Aspects Scale (BFAS). The BFAS is a 100-item scale developed by De Young, Quilty, and Peterson (2007). Derived from Goldberg's (1990) Abridged Big Five Dimensional Circumplex Inventory of the International Personality Item Pool, the BFAS is a measure of the five personality domains. Only the domains of openness to experience and neuroticism were used in this research. Both domains consisted of 20 items such as "I seldom feel blue" (neuroticism) and "I believe in the importance of art" (openness to experience) and was scored on a 5-point Likert scale (1-5), ranging from "strongly disagree" to "strongly agree". Higher scores in an individual domain indicated higher trait characteristics. The BFAS is a reliable measure of openness to experience (α=.85) and neuroticism (α=.89). Convergent validity has been established for openness to experience (r=.78) and neuroticism (r=.84), when compared to the Neo-PI-R (Young, Quilty & Peterson, 2007). Consistent with previous research, the domains of openness to experience and neuroticism were found to be reliable (α=.79, α=.91 respectively) in this study.

Spatial Working Memory. The CANTAB™ is a neurological testing battery that contains four tasks, Spatial Working Memory, Pattern Recognition Memory, Spatial Recognition Memory and Stockings of Cambridge. Only the Spatial Working Memory task was used in this research. The Spatial Working Memory task involves searching, through a process of elimination, for hidden blue tokens in coloured squares and moving them to an empty column on the right of the screen (see Figure 2). Task difficulty increases after four trials at each square level. The levels are three, four, six, and eight squares. The location of the squares and tokens changes between each trial to discourage search strategies. The rules of the Spatial Working Memory task are; only one token will be hidden at a time and a token will never be in the same place twice. This task is measured using total search errors (selecting boxes that are empty and revisiting a square where a token has already been found). The higher number of search errors indicates a lower score of spatial working memory. The Spatial Working Memory task is a well established, reliable measure of spatial working memory, with convergent validity satisfactory with measures of the same construct (Cambridge Cognition, 2013a).

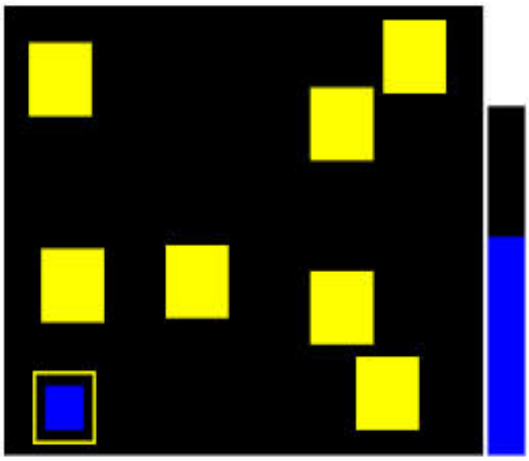

Figure 2. Image of the "Spatial Working Memory" task, adapted from the CANTAB™ (Image taken from http://www.camcog.com/cantab-tests.asp).

Procedure

Participants were booked for an assessment and asked to complete a self-administered questionnaire pack that was mailed to them in advance of the appointment. The assessment took place at ParkC, or the participant's home, and the time of the assessment was dependent on the participant's medication schedule. The demographic,

MMQ and BFAS measures were completed in the questionnaire pack. At the assessment, the research assistant checked through the questionnaires for missing data, and answered any questions regarding the questionnaires. The assessment runs through a specific sequence, starting with cognitive tasks and ending with the motor assessment. The assessment went for 2-3 hours and contained verbal, cognitive and motor tasks. There were nine cognitive tasks prior to the commencement of the CANTAB™, with the Spatial Working Memory measure the first test. There were four more cognitive tasks, and the assessment was completed following the motor assessment. The same procedure was followed after a two year period, and every two years thereafter.

Results

The PD population of this study when matched on age to a healthy normative sample recorded increased error scores on the Spatial Working Memory task as displayed in Table 1. Twenty eight participants scored in the deficit range when matched on age and gender to the normative sample. Normative data were provided by CANTAB™ (Cambridge Cognition, 2013b).

Table 1

Means and Standard Deviations for the SWM Total Errors of Current study and Normative Data aged between 60-69 years.

	Current Sample	Normative Sample	Exceeded Cut off Value
	M (*SD*)	*M* (*SD*)	*N*
Males	52.64 (22.83)	32.25 (24.52)	25
Females	39.73 (16.53)	36.62 (17.32)	3

Note: SWM = Spatial Working Memory.

The study variables are presented in Table 2. The control variable of age was retained in the analysis due to its significant correlation with the criterion variable. Gender was omitted from the analysis as it did not correlate with the criterion variable. None of the predictor variables were correlated with the criterion variable.

Table 2

Means, Standard Deviations and Inter-correlations between Control Variables, MMQ-Ability, Personality Domains and SWM Total Errors (N=97)

Measure	1	2	3	4	5	6	*M*	*SD*
1. Gender	-						-	-
2. Age	-.198	-					63.99	9.02
3. MMQ-Ability	-.072	-.075	-				51.02	11.27
4. Openness	-.012	-.010	.289*	-			66.39	8.59
5. Neuroticism	.104	-.127	-.445**	-.341**	-		52.24	11.81
6. SWM	-.067	.439**	-.142	-.050	.057	-	41.65	20.86

Note: MMQ-Ability = Meta-Memory Questionnaire Ability Subscale (MSE); SWM = Total number of errors on the Spatial Working Memory task (Time 2).
**p<.001, *p<.01

To test the moderation model two hierarchical multiple regressions were conducted. In regression one, age was entered in step one, MSE in step two, 0penness in step three and the interaction between MSE and openness in step four (see Table 3). In regression two, age was entered in step one, MSE and neuroticism in step two and the interaction between MSE and neuroticism in step three (see Table 4). The interaction terms were created by converting the raw scores of the MMQ-Ability subscale and the BFAS Openness and Neuroticism subscales using Grand Mean Centering (Field, 2013). The centered scores were then multiplied to provide the two interaction terms.

In regression one, age accounted for a significant 19.3% of the variance in SWM total errors, R^2 = .193, $F(1, 95) = 22.732$, p <.001. MSE at Time 1 explained a non-significant 1.2% of the variance in spatial working memory total errors at Time 2, ΔR^2 = .012, $\Delta F(1,94) = 1.410$, p =.238. Openness did not explain a significant amount of unique variance in spatial working memory total errors, ΔR^2 = .000, $\Delta F(1, 93) = .027$, p =.869. The interaction between MSE and openness explained a non-significant 1.1% of the variance in in spatial working memory total errors, ΔR^2 = .011, $\Delta F(1, 92) = 1.281$, p =.261 (f^2 = .01). In combination, the four predictor variables explained a significant 21.6% of the variance in SWM total errors, R^2 = .216, adjusted R^2 = .182, $F(4, 92) = 6.343$, p <.001 (f^2 = .28). MSE at Time 1 did not significantly predict spatial working memory at Time 2. Openness did not significantly moderate the relationship between MSE and spatial working memory. In regression two, age accounted for a significant 19.3% of the variance in SWM total errors,

R^2 = .193, $F(1, 95) = 22.732$, p <.001. MSE and neuroticism explained a non-significant 1.7% of the variance in spatial working memory total errors, ΔR^2 = .017, $\Delta F(2, 93)$ = 1.005, p =.370. The interaction between MSE and neuroticism explained a non-significant 2.2% of the variance in spatial working memory total errors, ΔR^2 = .022, $\Delta F(1, 92)$ = 2.595, p =.111 (f^2=.02). In combination the four predictor variables explained a significant 23.2% of the variance in spatial working memory total errors, R^2 = .232, adjusted R^2 = .198, $F(4, 92) = 6.941$, p <.001 (f^2=.30). Neuroticism did not significantly moderate the relationship between MSE and spatial working memory.

Table 3

Hierarchical Multiple Regression Analysis Predicting the Moderating Effect of Memory Self Efficacy and Openness (Time 1) on SWM Total Errors (Time 2).

Predictor	ΔR^2	*B*	β	[95% CI]	*sr²*
Step 1	.193**				
Age		1.016	.439	[.593, 1.440]**	.193
Step 2	.012				
MSE		-.203	-.110	[-.541, .136]	.012
Step 3	.000				
Openness		-.039	-.016	[-.505, .427]	.000
Step 4	.011				
MSE x Openness		.025	.113	[-.019, .068]	.011

Note: MSE = Memory Self Efficacy; SWM = Spatial Working Memory task.

**p<.001 (2-tailed)

Table 4

Hierarchical Multiple Regression Analysis Predicting the Moderating Effect of Memory Self Efficacy and Neuroticism (Time 1) on SWM Total Errors (Time 2).

Predictor	ΔR^2	*B*	β	[95% CI]	sr^2
Step 1	.193**				
Age		1.016	.439	[.593, 1.440]**	.193
Step 2	.017				
MSE		-.134	-.072	[-.516, .249]	.004
Neuroticism		.144	.081	[-.223, .511]	.005
Step 3	.022				
MSE x Neuroticism		-.019	-.156	[-.043, .005]	.022

Note: MSE = Memory Self Efficacy; SWM = Spatial Working Memory task

**p<.001 (2-tailed)

Discussion

This study explored the relationship between MSE and spatial working memory over a two year period in a PD population. This study also investigated the moderating effect of openness and neuroticism on the relationship between MSE and spatial working memory. Although the moderation model was not supported in the present study, the pattern of non-significant correlations between MSE and the personality domains on spatial working memory performance support the use of a moderator model (Field, 2013).

The present findings suggest that MSE did not predict spatial working memory over a two year period. It was anticipated that the way an individual perceives their memory ability would impact upon their actual spatial working memory performance (Valentijn et al., 2006). The present results were therefore surprising, given the relationship between perceived memory ability and actual WM performance reported in healthy and cognitively impaired older adults identified in the literature (Roberts et al., 2009; McDougall & Pfeifer, 2012). It is reasonable to suggest that the non-significant results of the study may be due to the lack of variability in the spatial working memory measure. A range of spatial working memory measures may have captured more variability in spatial working memory performance, compared to the sole Spatial Working Memory task used in this study. Future research should examine the relationship between MSE and other WM domains, such as visual and verbal working memory, as these WM domains may also be impaired in PD. This may provide insights into whether the MSE-memory performance relationship exists across all WM domains in PD. The non-significant results of this study,

however, were consistent with research that suggests that spatial working memory performance may actually predict MSE (Hess, 2005; Seeman et al., 1996). This is the first longitudinal study to examine the direction of the relationship between MSE and spatial working memory in PD. Future research should examine the nature of this relationship to further examine bi-directionality.

As openness is associated with positive memory beliefs, better memory and spatial abilities, it was anticipated that individuals higher for openness would demonstrate higher MSE and less errors on the Spatial Working Memory task (Williams et al., 2010; Booth et al., 2006). However this moderating effect was not demonstrated in the present study. The positive relationship between MSE and openness was supported in this study, suggesting that individuals who were higher in openness perceived their memory ability to be high (Soubelet & Salthouse, 2011). The overall high scores for openness in the present study were unusual, as previous research suggests that individuals who experience problems with their memory report lower openness (Comijs et al., 2002). It could be argued that the participants in this study may be at an early stage in the disease, and may not be aware of any problems with their memory. Also, as participants were excluded for scoring <24 on the MMSE, participants that were showing cognitive impairment were removed. This may explain why there was no impact of openness on spatial working memory two years later. Future research in ParkC should investigate this moderating relationship when Time 3 data becomes available to see if this relationship may manifest as PD progresses. This would provide a four year time frame where we may see more recognition of memory problems and more variance in actual memory performance. Although non-significant, the interaction between MSE and openness in the present study impacted on spatial working memory performance more than openness alone. Future research should investigate whether MSE or openness may be a better predictor of spatial working memory in PD. This may provide a better understanding of MSE and openness, with future implications for developing openness-specific interventions aimed at improving MSE and memory performance in PD.

Neuroticism did not moderate the relationship between MSE and spatial working memory performance in this study. As neuroticism is associated with negative memory beliefs and disengagement from cognitive activities, it was anticipated that individuals higher for neuroticism would demonstrate lower MSE and higher errors on the Spatial Working Memory task (Jelicic et al., 2003; William et al., 2010). The non-significant results are inconsistent with previous research, which suggests that higher neuroticism is

associated with poor working memory ability (Soubelet & Salthouse, 2011; Williams et al., 2010). However, the non-significant interaction between MSE and neuroticism accounted for the most variance in spatial working memory compared to both MSE and openness. This suggests that the MSE and neuroticism interaction may have a greater impact on spatial working memory than MSE and openness. Future research should compare the impact of neuroticism on MSE and spatial working memory to other personality traits, as other traits may significantly impact on MSE and spatial working memory. There was a relationship between MSE and neuroticism in this study, suggesting that individuals who were higher for neuroticism perceived their memory ability to be poor (Comijs et al., 2002). It is reasonable to suggest that the non-significant moderation results may be due to an underrepresentation of neuroticism levels and MSE at Time 1, compared to actual spatial working memory performance two years later. Future research should investigate this moderating relationship when Time 3 data becomes available to determine if this relationship manifests as PD progresses.

Additional limitations should also be acknowledged in this study. The MMQ Ability subscale has not been validated in PD, and may not be capturing perception of memory ability accurately in people with PD. Future research should involve the potential validation of the MMQ in a PD domain to ensure that MSE is being captured in PD. Also, less than 30% of participants in this sample demonstrated deficit for the spatial working memory task. This indicates that a majority of the participants may not be experiencing changes in their spatial working memory ability beyond that accounted for by healthy ageing. This also supports previous personality research and may suggest why the levels of openness and neuroticism were similar to that demonstrated by healthy ageing populations, rather than what would be anticipated in a population who experience problems with their memory (Comijs et al., 2002; Wortman et al., 2012). The significant influence of age on spatial working memory performance in this sample may have limited the impact of MSE and personality and may explain the non-significant results of this study. By investigating this relationship at Time 3, more variability in spatial working memory performance that is not due to ageing may become apparent. Future research should also investigate if certain levels of personality traits exist in a PD population. This may provide a better understanding of potential differences between personality traits in a PD population compared to healthy ageing populations.

Despite these limitations, the relationship between MSE and openness and neuroticism are apparent in the present study. Although MSE did not predict spatial

working memory, interventions targeting verbal working memory do improve MSE and memory ability in older adults (McDougall & Pfeifer, 2012). This suggests that further examination of MSE and spatial working memory in PD is warranted. Further examination of MSE may provide an understanding of how people with PD can improve their perception of their memory ability (Johnson, Pollard, Vernon, Tomes & Jog, 2005). Future research investigating the direction of the MSE and spatial working memory relationship may also provide an understanding of the appropriate stage at which to target interventions (Hess, 2005; Seeman et al., 1996). If future research establishes spatial working memory performance as predictive of MSE, clinical interventions targeting spatial working memory may improve perceptions of memory ability (Johnson et al., 2005). The moderating role of personality should also be investigated, as individuals higher in neuroticism may be more likely to develop negative perceptions about their memory following memory performance, compared to an individual higher in openness (Comijs et al., 2002). As people with PD may need a strong belief in their memory ability to continue to engage in social and cognitive tasks, increasing MSE may be an effective outcome for improving social and cognitive engagement and overall quality of life in people with PD.

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Literature Review

Parkinson's Disease Overview

Parkinson's disease (PD) is an idiopathic, degenerative neurological disease that results from the death of neurons in the substantia nigra area of the brain. These neurons are responsible for the production of dopamine, which acts as a chemical messenger between the substantia nigra and the Corpus Striatum (Ceravolo, Rossi, Kiferle & Bonuccelli, 2010). The role of the dopamine messengers is to relay motor and sensory signals in the brain, to produce purposeful and automatic movement. The loss of these dopaminergic neurons causes abnormal nerve firing, resulting in the impaired motor skills observed in PD (Schapira et al., 2009). PD research has also investigated the impairment of norepinephrine, which acts as a messenger of the sympathetic nervous system. The early degeneration of norepinephrine neurons may be associated with the non-motor symptoms observed in PD (Vazey & Aston-Jones, 2012).

PD is more prevalent in men compared to women, with onset occurring between 40 and 70 years of age (Access Economics, 2011). There is a growing incidence of early onset PD, in both diagnosis and research (Access Economics, 2011). In terms of disease progression, although it varies between individuals, the median lifespan of living with PD from diagnosis is 12.2 years. However, this prognosis may be improved with early diagnosis and treatment, with dopamine medications being the leading treatment of PD symptoms (Schapira, 2010). Although PD is idiopathic, there is some evidence to suggest that i) accelerated aging neuron deterioration, ii) oxidative damage, iii) environmental toxins damaging neurons, and iv) family predisposition, may all be possible causes of PD (Access Economics, 2011).

Although the onset of symptoms varies between individuals with PD, both motor and non-motor symptoms are characteristic of PD. Motor symptoms are the most commonly recognised symptom for diagnosis (Schapira et al., 2009). The main motor symptoms of PD include; tremor, ridigity, Akinesia and Bradykinesia and poor postural stability (Schapira et al., 2009). Tremor often occurs first in the hand, usually unilateral, however may progress to other parts of the body and become bilateral. Rigidity refers to stiffness in the limbs and face, which restricts movement. Akinesia and Bradykinesia refers to slow and unpredictable movements which are often debilitating and impact on everyday activities. Poor postural stability may result in poor balance and coordination (Schapira et al., 2009).

Non-motor symptoms (NMS) often precede motor symptoms. They are not, however, usually recognised until the motor symptoms occur (Schapira et al., 2009). NMS

of PD become more prominent as PD severity increases (Ceravolo et al., 2010). NMS of PD include; cognitive dysfunction, which may range from mild impairment to possible dementia; neuropsychiatric symptoms, such as depression and anxiety; Sleep disorders, such as REM and excessive day time sleepiness, as well as autonomic symptoms, such as fatigue, sexual dysfunction and elevated blood pressure (Ceravolo et al., 2010; Schapira et al., 2009). NMS are often overshadowed by motor symptoms and are often inadequately treated, despite being associated with poor quality of life. Memory is reported as the most frequently impaired cognitive domain in PD (Aarsland et al., 2010). It is considered 'unsurprising' that working memory is impacted in PD, given the relationship between PD and deficits in the prefrontal cortex (McKinlay, 2013; Pillon et al., 1998). It is important for PD research to investigate the impact of NMS such as memory, as NMS are a leading cause of hospitalisation and institutionalisation in PD patients (Ceravolo et al., 2010).

Working Memory

Working memory (WM) is a limited storage capacity system that temporarily stores and manipulates information that is necessary to complete cognitive tasks (Baddley, 2000). Originally proposed by Baddeley and Hitch (1974), the WM framework introduced the concept of a multi-component system and its function in complex cognition, as opposed to earlier unitary storage models. However, Baddeley modified this framework and proposed a new component to WM, focusing on the integration of information between the components, rather than each component in isolation (Baddeley, 2000; Baddeley & Hitch, 2010). The new model proposed that WM was capable of long-term, 'crystalised intelligence' systems (such as language and learning) and 'fluid intelligence' (temporary storage) and should no longer be considered separate to long-term memory (LTM; Baddeley & Hitch, 2010). The revised framework of WM consists of four components; the central executive, the episodic buffer, the phonological loop and the visuo-spatial sketchpad (Baddeley, 2000; Repors & Baddeley, 2006).

The central executive is responsible for manipulating information and controlling the other subcomponents in WM. The central executive is a limited control system encompassing four main capacities; the ability to divide and switch attention and to focus and retrieve information from LTM through conscious awareness (Repors & Baddeley, 2006). Controlled by the central executive, the episodic buffer is a temporary, limited storage system that combines information from a variety of different sources. The episodic buffer is a passive store that retains information integrated and maintained into coherent episodes, and is responsible for sending and retrieving information between the visuo-

spatial and verbal subcomponents and episodic LTM (Baddeley & Hitch, 2010). The phonological loop temporarily stores auditory information, which may decay unless utilised by articulatory rehearsal. This process is responsible for retrieving and rearticulating speech information in the phonological store (Baddeley & Hitch 2010). A component of verbal working memory, the phonological loop receives a large focus for research into WM (Repors & Baddeley, 2006).

The visuo-spatial sketchpad is a crucial element of WM as it is necessary in performing many cognitive tasks relating to non-verbal memory. These tasks include; geographical location, planning spatial tasks and mental maps (Baddeley & Hitch, 2010). The visuo-spatial sketchpad is responsible for storing and manipulating both visual and spatial information (Baddeley, 2000; McAfoose & Baune, 2009). Although the sketchpad is included as one component in the WM model, research suggests that visual and spatial information is stored, manipulated and maintained in individual processes (Baddeley & Hitch, 2010). This has lead to the suggestion that the visuo-spatial sketchpad is an individual subcomponent of WM, rather than a unitary system (Baddeley & Hitch, 2010; McAfoose & Baune, 2009). The basis for separating the visuo-spatial sketchpad into visual and spatial working memory is also provided in research into WM impairments, identifying that while one subcomponent may be impaired, the other continues to function (McKinlay, 2013; Pillon et al., 1998; Siegert, Weatherall, Taylor & Abernethy, 2008).

Working Memory and Parkinson's Disease

Due to the impairment of dopaminergic neurons and the resulting depleted neural activity in the prefrontal cortex (associated with WM), research has addressed possible WM impairments in PD (McKinlay, 2013; Pillon et al., 1996). Although research into WM in PD suggests there is some WM impairment, there are conflicting results into the precise nature of the impairment (Johnson & Galvin, 2011; Possin, Filoteo, Song & Salmon, 2008; Siegert et al., 2008). For example, research suggests that verbal working memory and visual-spatial memory are both impaired, however, are they both impaired to the same degree? Based on this premise, WM research in PD provides conflicting evidence for both preserved and impaired WM performance (McKinlay, 2013).

A meta-analysis by Siegert et al (2008) reported that both verbal working memory and visuo-spatial working memory were impaired in participants with PD compared to non-PD participants. Consistent with previous research, the results also suggest that visuo-spatial working memory impairments are more pronounced in PD, compared to verbal working memory (Aarsland et al., 2010; Johnson & Galvin, 2011). Research has also

suggested that spatial working memory may be more impaired than visual working memory because of individual processing deficits. However, there is some argument over whether the possible differences between verbal, visual and spatial working memory can be attributed to deficits in individual processes, or if spatial working memory impairment may be due to confounding variables, such as task complexity and anti-Parkinson's medication (Marini, Ramat, Ginestroni & Paganini, 2003; Pillon et al., 1998; Possin et al., 2008; Siegert et al., 2008).

Research into task complexity in WM has examined the difference between simple and complex WM tasks, as well as task complexity based on delay. Possin et al (2008) reported that visuo-object WM was relatively unimpaired in short, simple delay tasks in mild to moderate PD. Spatial working memory was, however, impaired regardless of interval delay. These results are consistent with research by Siegert et al. (2008), suggesting that although PD participants were more impaired on complex verbal tasks compared to simple tasks, there was no evidence of task difficulty impacting on SWM impairment. This suggests that WM impairment is greater in spatial working memory tasks compared to verbal and visual working memory tasks, and provides evidence of specific impaired encoding processes of information that cannot be attributed to task difficulty (Pillon et al., 1998; Siegert et al., 2008).

The effect of anti-Parkinson's dopamine medication on WM is debateable and unclear. WM research in the early stages of PD suggests that there is no difference between medicated and non-medicated Parkinson's participants except in verbal fluency. Verbal fluency had improved in medicated participants, compared to non-medicated participants (Marini et al., 2003). For severe PD, medicated participants were impaired for all aspects of WM. However, in mild, medicated Parkinson's participants, only spatial working memory remained impaired (Marini et al., 2003; Possin et al., 2008). This provides evidence to support the idea that there are selective WM process deficits in PD. Unlike verbal and visual WM, spatial working memory is impaired in PD, regardless of dopamine medication. This research suggests that there is a specific impairment of spatial working memory in PD and that visual and spatial working memory can be considered as separate components of WM (Marini et al., 2003; Pillon et al., 1998; Possin et al., 2008; Siegert et al., 2008).

Memory Self-Efficacy

Memory Self-Efficacy (MSE) is based on self-efficacy theory (SET) by Bandura (1977). SET is one's perception of their capability to successfully achieve a behaviour/goal

required to produce a positive outcome. Bandura (1977) suggested that there were four factors influencing self-efficacy; behaviour, the environment, personal and cognitive. Although the factors are all interrelated and affect one another, the cognitive factor is considered the most important aspect of self-efficacy. Bandura (1989) proposed that self-efficacy can both hinder and improve cognitive performance, based on a person's beliefs about their memory ability. For example, people who perceive themselves as inefficacious are more likely to envision themselves as failing and this undermines their performance. Self-efficacy operates in a cycle, whereby perceived failures reinforce future inefficacy and perceived triumphs reinforce strong self-efficacy (Bandura, 1989). MSE is one's belief in their ability to use memory effectively to achieve goals based on their cognitive ability.

MSE is most commonly researched in aging populations, as individuals typically expect that their memory will decline with age (McDougall, 2009). Valentijn et al (2006) reported that older adults experience a greater perceived loss in their memory ability compared to young adults. MSE is associated with memory performance, and may be considered a predictor of memory ability. However, research suggests that the relationship between MSE and memory performance should address the possible effects of age, cognitive decline and personality characteristics (Comijs, Deeg, Dik, Twisk & Jonker, 2002; Roberts, Clare & Woods, 2009).

Working Memory and Memory Self-Efficacy

Research suggests there is a positive relationship between MSE and WM performance. There are, however, some inconsistencies regarding the strength of the relationship (Beaudoin & Desrichard, 2011). A meta-analysis by Beaudoin & Desrichard (2011) suggested that insignificant results demonstrated by some studies were due to a lack of statistical power. Beaudoin & Desrichard suggest there is a relationship between MSE and memory performance, and that MSE is a predictor of memory performance (Hoffman & Schraw, 2009). Research has investigated age and cognitive impairment as potential moderators of the relationship between MSE and WM performance. The effect of ageing and cognitive impairment impacts upon a person's perceptions of their memory ability and memory performance (Comijs et al., 2002; McDougall, 2009; Valentijn et al., 2006). As age and cognitive impairment is associated with PD, the impact of age and cognitive impairment should be considered on the MSE and WM relationship in a PD population.

Memory decline is an expected aspect of aging, with older adults attributing faulty performance to a decline in memory capacity and not to knowledge error. It is uncertain whether this results from an actual observed change in memory ability, or from the

expectation of memory decline (Valentijn et al., 2006). The cycle of MSE affecting memory performance, and in turn strengthening beliefs, was investigated in a longitudinal study by Valentijn et al. 2006. This study suggested that changes in MSE are mirrored by changes in memory performance (Valentijn et al., 2006). Individuals who had low MSE improved less on WM tasks compared to those who reported higher MSE. It was also suggested that as the risk of cognitive impairment increased with age, the level of awareness of cognitive deficits impacted the relationship between MSE and memory performance. Those who were more aware of deficits were less likely to participate in memory activities (Roberts et al., 2009). Although gender and depression have been investigated as potential confounding variables, there was no evidence to suggest that this affects the impact of age and cognitive impairment on MSE and WM (Valentijn et al., 2006).

Much of the research in healthy aging and cognitive impairment has focused on verbal working memory and MSE (McDougall & Pfeifer, 2012). This is noted as a limitation of the research (Siegert et al., 2008). Studies of the relationship between MSE and spatial working memory have demonstrated conflicting results. This may explain why research focuses on verbal working memory. Studies of spatial working memory and MSE have been conducted in healthy, younger adults, who are unlikely to identify themselves as having any changes in memory performance (Beaudoin & Desrichard, 2011). It is important to further investigate the relationship between MSE and spatial working memory, particularly in aging populations with cognitive impairment, as memory and visuo-spatial abilities are most commonly impaired in PD (Aarsland et al., 2010).

The best evidence for the relationship between MSE and Memory performance has been found in cross-sectional studies. However, the nature of cross-sectional data impedes any conclusions that could be drawn about causality (Hess, 2005). A longitudinal study by Seeman, McAvay, Merrill, Albert and Rodin (1996) suggested that stronger MSE predicts better levels of performance in some cognitive domains. However, Seeman et al (1996) also suggested that memory performance may have a bigger effect on MSE rather than vice versa and may explain the inconsistent results in previous studies. This is in contrast to evidence that suggests interventions designed to increase MSE are associated with improved memory performance (Hess, 2005). Also, insufficient change on memory measures over time has prevented adequate evaluation of the impact of MSE on memory performance. Seeman et al. (1996) suggested that more longitudinal studies are required to investigate the cause and effect relationship between MSE and memory performance.

Personality and Memory

Personality is a combined number of characteristics that influence a person's behaviours, cognition and emotion (Goldberg, 1990). The Five Factor Model of personality (The Big 5) proposes that there are five distinct categories of personality; Openness to experience, Conscientiousness, Extraversion, Agreeableness and Neuroticism (Goldberg, 1990). Although personality and memory research often yields conflicting results, there is general agreement that all five personality domains have a small, but significant, relationship with cognition (Booth, Schinka, Brown, Mortimer & Borenstein, 2006).

The strongest individual relationships between personality and cognition have been found for Openness to experience and Neuroticism (Williams, Suchy & Kraybill, 2010). Openness has the strongest relationship with memory. Those higher for openness demonstrate better cognitive, memory and spatial abilities. In contrast, those who score highly for neuroticism do not perform well in WM tasks (Williams et al., 2010). Research into healthy ageing and personality suggests that age-related changes in personality may lead certain characteristics to influence cognition more than others. Increased age is often associated with lower levels of neuroticism and openness and with higher levels of conscientiousness and agreeableness (Soubelet & Salthouse, 2011; Wortman, Lucas & Donnellan, 2012).

Although lower levels of neuroticism and openness are associated with increased age, this may not be representative of the ageing population who experience problems with their memory. The impact of neuroticism on cognitive ability is unclear in ageing research, despite higher levels of neuroticism in older adults being associated with mild cognitive impairment and poor decision making (Jelicic, Bosma, Ponds, Boxtel, Houx & Jolles, 2003; Williams et al., 2010). This correlation between memory complaints and higher levels of neuroticism suggests that actual memory decline may impact upon a person's personality more so than ageing (Williams et al., 2010). Research into the relationship between openness and cognitive functioning suggests that the two have a unique relationship that may serve to prevent cognitive decline (Williams et al., 2010). This theory proposes that those who maintain a higher level of openness across the lifespan will have better memory performance, and possibly reduce the risk of dementia (Booth et al., 2006). This may explain why openness decreases in adults with cognitive impairment, as engagement and belief in memory ability decreases (Soubelet & Salthouse, 2011). Research has also suggested that individuals with lower levels of neuroticism and high levels of openness show greater WM performance, regardless of age. This supports the

idea that beliefs about one's memory ability and deficits play a larger role in the personality-memory relationship in contrast to ageing (Williams et al., 2010).

Personality, Memory Self-Efficacy and Working Memory

The relationship between personality, memory self-efficacy and WM is complicated and unclear (Demetriou, Kyriakides & Avraamidou, 2003). Although research has established a link between MSE and WM and between personality and WM, little research has examined the relationship between all three. Many studies have alluded to possible moderators on the relationship between MSE and WM, such as personality (Beaudoin & Desrichard, 2011; Possin et al., 2008). Some studies have suggested that the way a person perceives their memory ability may mediate the relationship between personality and memory. Such research, however, has only considered self-awareness of intelligence (Cavanaugh & Green, 1990). Cavanaugh & Green (1990) suggested that the relationship between MSE and memory performance was 'crooked' and could not truly be evaluated without considering personality as a potential moderator. This is because personality encompasses aspects of self-efficacy and memory performance (Cavanaugh & Green, 1990). A longitudinal study by Valentijn et al. (2006) suggested that the combination of MSE and personality has a stronger impact on memory performance over time, compared to individual contributions. This is due to the close relationship between MSE and personality. This theory has been supported by a meta-analysis indicating a need for further experimental studies to investigate this moderating relationship (Beaudoin & Desrichard, 2011).

Research suggests that maintaining high openness and low neuroticism may serve as a protective factor against impaired memory (Booth et al., 2006). This is supported in both MSE and personality and MSE and WM research. High neuroticism is associated with poor WM performance, and disengagement from social and cognitive activities. In contrast, individuals high in openness are more likely to show greater WM performance, have positive memory beliefs and a willingness to adopt strategies to improve on perceived deficits (Roberts et al., 2009; Soubelet & Salthouse, 2011; Williams et al., 2010). By investigating the relationship between memory self-efficacy, personality and spatial working memory in a PD population, an understanding of the impact of personality may assist in improving spatial working memory performance. The development of personality specific interventions may combine programs aimed at improving MSE and engagement in cognitive tasks (Booth et al., 2006; Beaudoin & Desrichard; 2011; Demetriou et al., 2003). This may provide possible improvements in quality of life for people with Parkinson's.

Aims

This research will investigate the impact of personality on the relationship between actual and self-reported memory in PD over a two year period. No research has investigated openness to experience and neuroticism as potential moderators of the MSE and SWM relationship in a PD domain. However, healthy aging and cognitive impairment studies have suggested that a possible link between the three variables should be investigated. A longitudinal analysis may provide evidence for the direction of the MSE and SWM relationship that cannot be established through cross-sectional research (Field & Hole, 2003). The primary hypothesis of the study is that after controlling for age and gender, MSE at Time 1 will significantly predict spatial working memory performance at Time 2 (Figure 1). The secondary hypotheses are (i) after controlling for age and gender, openness to experience will significantly moderate the relationship between MSE and spatial working memory in PD (Figure 1a), and (ii) after controlling for age and gender, neuroticism will significantly moderate the relationship between MSE and spatial working memory in PD (Figure 1b).

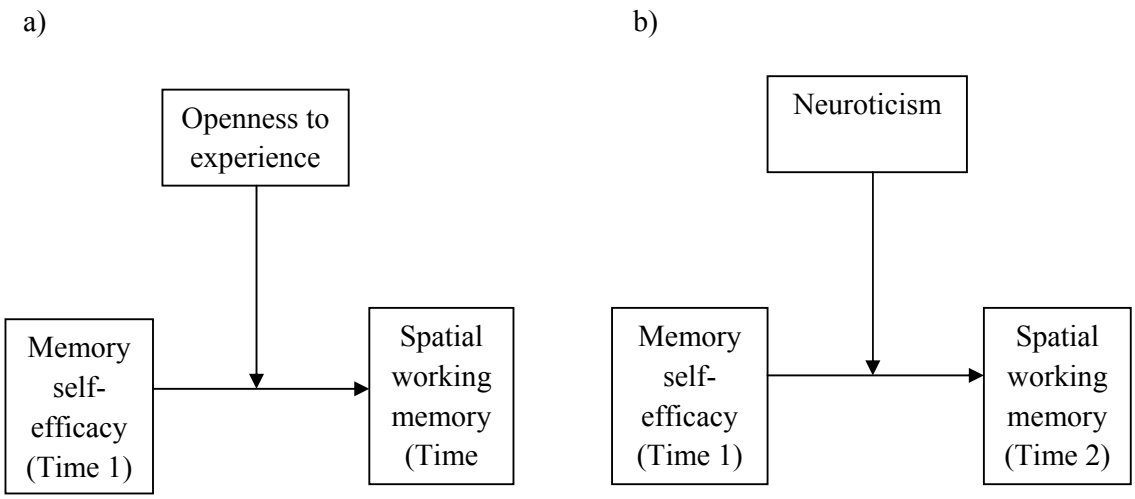

Figure 1. The moderator model of the memory self-efficacy and spatial working memory relationship with a) openness to experience as a potential moderator, and b) neuroticism as a potential moderator.

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Supplementary Material A

Ethics Approval Number

From: Research Ethics
Sent: Monday, 30 May 2011 11:28 AM
To: Meghan THOMAS
Cc: Stephanie WHITWORTH
Subject: RE: ParkC Ethics

Extension? Hi Meghan

Project 2736 - Cognitive and motor heterogeneity in idiopathic Parkinson's disease

Is this the project you mean? If so, ethics approval is until 31 December

2014. Cheers
Kim

Kim Gifkins, Research Ethics Officer, Office of Research & Innovation, Edith Cowan University, 270 Joondalup
Drive, Joondalup, WA 6027 **research.ethics@ecu.edu.au** Tel: +61 08 6304 2170 **| Mobile: 0428 035 397 |** Fax:
+61 08 6304 5044 **|** CRICOS IPC 00279B

From: Meghan THOMAS
Sent: Monday, 30 May 2011 9:02 AM
To: Kim GIFKINS
Cc: Stephanie WHITWORTH
Subject: ParkC Ethics Extension?

Hi Kim,

Stephanie has been working on some amendments to our ParkC Ethics application and noticed that our approval is until July 2011.

We have been successful in securing a further 3 years worth of funding, so the study will be continuing.
Could we please extend our ethics approval until March 2014?

Kind regards
Meghan

Dr Meghan Thomas (PhD)

Director Parkinson's Centre (ParkC)/
Postdoctoral Research Fellow (Neurological Cell Replacement Therapies)

Phone: +61-8-6304 3560/+61-8-6488 7515
Fax: +61-8-6304 2899
Web: www.ParkC.org.au

Correspondence:
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Building 21
270 Joondalup Drive
Joondalup, WA, 6027

Supplementary Material B

Information Sheet

INFORMATION SHEET

JOONDALUP CAMPUS
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☎ (08) 6304 3560
ParkC@ecu.edu.au
www.ParkC.org.au
ABN 54 361 485 361 CRICOS PROVIDER 00301J

Project titled: COGNITIVE AND MOTOR HETEROGENEITY IN IDIOPATHIC PARKINSON'S DISEASE.

Chief Investigator(s): Dr Meghan Thomas, PhD *(Director and Postdoctoral Research Fellow, ParkC, Edith Cowan Health and Wellness Institute, Edith Cowan University),* Miss Caitlin Timms *(Research Assistant, ParkC, Edith Cowan Health and Wellness Institute, Edith Cowan University).* **Co-Investigator(s):** Dr Romola Bucks, PhD *(UK Trained Clinical Neuropsychologist and Lecturer, School of Psychology, University of Western Australia)*, Dr Andrea Loftus, PhD *(Lecturer, School of Psychology, University of Western Australia),* Dr Natalie Gasson, PhD *(Undergraduate co-ordinator, Lecturer, School of Psychology, Curtin University).*

We would like to invite you to participate in the following research which will investigate the relationship between motor (i.e. balance, walking, tremor, rigidity), and non-motor (i.e., problems with memory, thinking, and mood) symptoms of Parkinson's disease (PD). Information regarding the relationship between the motor and non-motor symptoms will to be used to identify subtypes of PD.

Currently, the cause of PD is unknown. It is possible that some (but not all) individuals may have a genetic predisposition to developing PD and the current research aims to explore this further.

Please take time to read the following information carefully and discuss it with others if you wish.

What are the possible benefits of taking part?
The information we gain from your participation will help us better to understand the motor (balance, walking, tremor, rigidity) cognitive (thinking and memory) and affective (mood) problems that can occur as a result of PD. The information we gain from your participation will help us to identify subtypes of PD and the identification of subtypes will have implications for the clinical management of future patients with PD.

Why have I been invited to participate in this research?
You have been invited to participate in this research because you have been diagnosed with PD or Parkinsonism.

What will I be asked to do?
There are three parts to this study: Part 1) involves the completion of questionnaires or surveys; Part 2) involves some computer and paper-based assessments; and Part 3) involves an assessment of motor (i.e. balance, walking, tremor, rigidity) symptoms.

Part 1: We will provide you with a questionnaire package via post and ask that you complete some surveys regarding your mood, memory, and personality, how sleepy you are during the day and possible sleep difficulties, how your Parkinson's symptoms influence your everyday life, and how you cope with things in general. All of these surveys are designed to be self-completed; therefore, you may complete the surveys at

home and bring them with you to your appointment at ParkC, if you decide to participate in Part 2 of the study. You are also free to complete all or part of the questionnaires at the end of your appointment at ParkC if you wish. A research staff member from ParkC will sit with you and discuss any questions you may have regarding the questionnaires. If you do not wish to take part in Part 2 of this research, you may still complete the questionnaires and we will provide you with a reply paid envelope to return your questionnaires.

Part 2: If you are happy to participate in Part 2 of this research, we will go over the information sheet with you when you arrive at ParkC, explain what is going to happen during the appointment, and answer any questions you might have. You will then be asked to participate in some tasks that are designed to look at your memory and thinking skills. These will be both paper-based and computer-based tasks. The session will be made as enjoyable as possible for you; however some of these tasks can be challenging. If you feel at any point during the assessment that you would like to stop, please tell the research staff and they will end the session immediately. You do not have to give a reason why and you will not be asked any further questions.

Part 3: Lastly, you will be asked to perform some simple motor (i.e. balance, walking, tremor, rigidity) tasks as part of the Unified Parkinson's Disease Rating Scale (UPDRS), a standardised assessment for the motor symptoms of PD. These motor tasks will include: finger tapping, hand rotations, fist clenching/opening, finger to nose movements, leg and toe tapping, rising from a chair, and a 10 meter walk. The investigator will also give you a slight pull on the shoulders to assess your balance and will stand behind you to provide support should you become unbalanced. Assessments of speech, facial expression, rigidity (stiffness of neck, arms and legs), and tremor will be made via observation during this assessment period. You will also be asked some questions regarding dyskinesias (involuntary movements), fluctuations in functioning due to medications cycles and dystonia (painful cramps and/or muscle spasms) which you may or may not experience. **All of these assessments will be videotaped to allow for independent review and rating by experts in the field of Parkinson's, although you can decline to have the session videotaped.** We will also take a measurement of your height, weight and waist circumference.

The motor assessment requires manipulation of the hips and legs. Please wear comfortable clothing; trousers are preferred.

Throughout the appointment you will be encouraged to ask questions and while the testing is anticipated to take no more than 2 hours, you will be given regular breaks.

Blood sample for Genetic Analysis

There is a fourth optional part of this project. As part of the appointment at ParkC, we ask participants if they would be happy to donate a small sample of blood so that we can look at genetic make-up (i.e. your DNA). **Please note that the decision to have a blood sample taken is completely optional and forms a different part of the study. You can decide not to have a blood sample without affecting any other data we collect about you for the study. Your participation will be of equal value, with or without the blood sample**.

Blood and DNA samples will be stored for the length of this research project and will be analysed for a range of DNA markers.

Initially we will screen for the known genetic mutations that cause familial PD. These mutations occur in the SNCA, LRRK2, Parkin, PINK1, DJ-1 and Parkin 9 genes. Familial PD occurs in only 10% of PD cases so is uncommon. If we find a known genetic cause of PD we will (with your consent) inform your treating physician who will be able to arrange appropriate Genetic Screening to confirm our research findings.

We also intend to screen for a range of genetic measures that may be associated with the various aspects of PD. The technology for genotyping DNA is changing rapidly and is producing more and more complex data. Further the known genetic influences that may affect different aspects of PD are still unclear. Therefore we

free to withdraw at any time and you do not need to give a reason. A decision to withdraw from this research will not affect the standard of care you receive and there will be no effect on your legal rights, medical care, or your relationship with the hospital or your doctors. You are also welcome to participate in other research projects conducted by ParkC if you decide to withdraw from this particular study.

If you do decide to withdraw, we will ask you whether you are happy for us to use the data that we might have already collected from you. If you are not happy for us to use any of the data collected from you, any data relating to your participation in this study will be destroyed.

Who is organising and funding the research?
ParkC is funded by Edith Cowan University (ECU), donations from the McCusker Foundation, the Rotary Club of Morley, and donations from members of the public and Parkinson's community.

Who has approved the study?
This research has been approved by Edith Cowan University's Human Research Ethics Committee, Parkinson's Western Australia (PWA) Inc., and Joondalup Health Campus Human Research Ethics Committee.

Who can I contact about this study?
If you have any questions about this study or would like more information, please contact either Miss Caitlin Timms or Dr Meghan Thomas on (08) 6304 3560 or email ParkC@ecu.edu.eu

What if there is a problem and I want to make a complaint?
If you have any concerns of an ethical nature or complaints about the manner in which the research is conducted, please contact (Kim Gifkins: Research Ethics Officer) of ECU's Human Research Ethics Committee on: (08) 6304 2170 or email research.ethics@ecu.edu.au. Additionally, you can contact the Joondalup Health Campus Human Research Ethics Committee through the Executive Office on (08) 9400 9404. Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome.

What will happen to the study results?
We will let you know the results of the study in our annual newsletter which will be posted via mail and on the ParkC website (www.ParkC.org.au). However, if you would like to know anything further please feel free to contact the research team at ParkC before then and we will be happy to share the findings with you. The results of this study will also be communicated via presentations at National and International conferences as well as being written into manuscripts which will be submitted to peer-reviewed journals. All of your identifying features will be removed in such cases.

Do I get to keep a copy of the Information Sheet and Consent form?
You will be given a copy of this Information Sheet to keep. If you decide to take part in this research and sign the consent form, you will be given a copy of this signed consent form for your records also.

Dr Meghan Thomas
Director, Postdoctoral Research Fellow
Parkinson's Centre (ParkC)
Edith Cowan University
Phone: (08) 6304 3560
Fax: (08) 6304 2499
Email: m.thomas@ecu.edu.au

Caitlin Timms
Research Assistant
Parkinson's Centre (ParkC)
Edith Cowan University
Phone: (08) 6304 3560
Fax: (08) 6304 2499
Email: caitlin.timms@ecu.edu.au

Supplementary Material C

Consent Form

CONSENT FORM

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Joondalup, Western Australia 6027
☎ (08) 6304 5560
ParkC@ecu.edu.au
www.ParkC.org.au
ABN 54 361 485 361 CRICOS/PC 00218

Project titled: COGNITIVE AND MOTOR HETEROGENEITY IN IDIOPATHIC PARKINSON'S DISEASE.

Please tick box

1. I have read and understood the 'Information Sheet' for this study. ☐
2. The nature and the possible effects of this study have been explained to me. ☐
3. Any questions that 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 the UPDRS, a standardised assessment of the motor symptoms of Parkinson's will be administered and that this assessment involves a number of simple motor tasks, an assessment of balance, and various observations of speech, tremor, rigidity, and posture. ☐
6. I understand that I will be videotaped undertaking the assessment of motor (i.e. balance, walking, tremor, rigidity) symptoms ☐
    a. I consent for the video files of my UPDRS assessment to only be used in this study for the purposes of confirming my diagnosis of Parkinson's and that the recording will be deleted upon completion of the study. ☐
    b. I consent for the video file of my UPDRS assessment to be used in future approved research projects conducted at ParkC which are in the same general area of Parkinson's research. ☐
7. I consent to my results being released to my treating physician/neurologist if requested. ☐
8. I understand that all research data will be securely stored at ParkC, Edith Cowan University, for a minimum period of five years following the study end date. I also understand that the data will be securely stored on password protected computers and locked cabinets at ParkC until no longer required, at which time it will be destroyed. ☐
9. I understand that there are no foreseeable risks associated with this research, aside from the possibility of fatigue and minimal risk of falls associated with the balance assessment conducted in Part 3 of the research. ☐

10. I agree that research data for the study may be published and that I will not be identified as a participant. ☐
11. 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 and/or research in the same general area. ☐
12. I agree to participate in this investigation and understand that I may withdraw at anytime 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. ☐
13. I agree to donate a sample of blood for research purposes. I understand that this sample will be used for the purpose of genetic tests.
    a. I consent for my blood samples to only be used in this study and that they will be destroyed at the completion of the study ☐
    b. I consent for my blood sample to be used as explained so far and for any other analysis that may arise during the course of the study. ☐
    c. I consent for my blood samples to be held for future studies that may or may not be related to Parkinson's but that have received ethics approval from a recognised institution. ☐
    d. I consent for ParkC to inform my treating physician if a mutation in a known familial PD gene is found ☐

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 Investigator_____

Signature of Investigator_____Date_____

Follow-Up Consent Form

CONSENT FORM

JOONDALUP CAMPUS
270 Joondalup Drive, Building 21; Level 5
Joondalup, Western Australia 6027
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ParkC@ecu.edu.au
www.ParkC.org.au
ABN 54 361 485 361 CRICOS IPC 00279B

Project titled: COGNITIVE AND MOTOR HETEROGENEITY IN IDIOPATHIC PARKINSON'S DISEASE.

ParkC is happy to share clinically appropriate test results with the doctor who treats your Parkinson's, should this be helpful for your care. This also streamlines assessment of your Parkinson's. If your treating doctor contacts us, do you consent to your assessment results being forwarded to them?

Please circle:

I **DO** / **DO NOT** consent to the release of my results to my treating doctor.

A very small percentage of people with Parkinson's go on to develop cognitive problems (i.e. thinking and memory), including dementia. Our Human Research Ethics Committee prefers that we ask you, in advance, for permission to approach you regarding follow-up assessment in the event of cognitive decline at some stage in the future. This does not affect your right to change your mind.

Please circle:

I **WOULD/ WOULD NOT** like to be assessed as part of the follow-up of this study.

I **WOULD/ WOULD NOT** like to be contacted about other research projects.

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 Investigator_____

Signature of Investigator_____Date_____

Supplementary Material D

UK Parkinson's Disease Society Brain Bank Clinical Diagnostic Criteria

(Hughes AJ et al. J Neurol Neurosurg Psychiatry 1992;55:181-4)

Inclusion criteria	Exclusion criteria	Supportive criteria
Bradykinesia (slowness of initiation of voluntary movement with progressive reduction in speed and amplitude of repetitive actions)	History of repeated strokes with stepwise progression of parkinsonian features	(Three or more required for diagnosis of definite PD)
	History of repeated head injury	Unilateral onset
	History of definite encephalitis	Rest tremor present
And at least one of the following:	Oculogyric crises	Progressive disorder
Muscular rigidity	Neuroleptic treatment at onset of symptoms	Persistent asymmetry affecting side of onset most
4-6 Hz rest tremor	More than one affected relative	Excellent response (70-100%) to levodopa
Postural instability not caused by primary visual, vestibular, cerebellar, or proprioceptive dysfunction	Sustained remission	Severe levodopa-induced chorea
	Strictly unilateral features after 3 yr	Levodopa response for 5 yr or more
	Supranuclear gaze palsy	Clinical course of 10 yr or more
	Cerebellar signs	
	Early severe autonomic involvement	
	Early severe dementia with disturbances of memory, language, and praxis	
	Babinski sign	
	Presence of cerebral tumour or communicating hydrocephalus on CT scan	
	Negative response to large doses of L-dopa (if malabsorption excluded)	
	MPTP exposure	

Supplementary Material E

Demographic Questionnaire

"Cognitive and motor heterogeneity in idiopathic Parkinson's"

Medical History and Demographic

FOR OFFICE USE ONLY: to be completed by administrator
Time of last medication dose:_____ Session Commenced _____

First Name:	**Last Name:**
Date of Birth:	**Sex:** M ☐ F ☐ (please tick)
Handedness: Right ☐ Left ☐ Ambidextrous ☐ (please tick)	
Marital Status: Single ☐ Married ☐ De Facto/Co-habitating ☐ (please tick) Divorced/Separated ☐ Widowed ☐ Declined to Say ☐	

Contact Details:	
Address:	
Suburb:	
State:	Post Code:
Contact Number:	
Home Phone:	Mobile:
Email:	
Emergency Contact:	
Name:	
Phone:	
Relationship:	

Diagnosis Information: Parkinson's	
Diagnosis date (month/year):	
Who were you diagnosed by?	Neurologist ☐ NAME:
	GP ☐ NAME:
	Other ☐

Are you currently seeing a neurologist? Yes ☐ No ☐ (please tick)
What is the name of your neurologist?
Are you a member of Parkinson's Western Australia Inc (PWA)? Yes ☐ No ☐ (please tick)
Is your Parkinson's thought to be caused by medications ? Yes ☐ No ☐ If yes, do you know the class of drug or the medication which caused your Parkinsonism? Yes ☐ No ☐ What was/is it? _____

Medication History				
What Medications (including anti-Parkinson's) do you currently take?	Dosage (mg)	Number Tablets	Number of times 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., years/months)				
What are the reason/s and/or medical conditions requiring you to take other medication aside from your anti-Parkinson's medications				
Wearing-off is a complication that can occur after a few years of using levodopa to treat Parkinson's. During wearing-off, symptoms of Parkinson's start to return or worsen before the next dose of levodopa is due, and improve when the next dose is taken Do you experience symptoms of 'wearing off' Yes ☐ No ☐ (please tick) If 'YES', What times of the day do you feel 'at your best' _____ _____ If 'YES' how many 'on' hours do you typically experience 'at your best' _____				

MEDICAL HISTORY

1) Smoking

(a) Are you or have you ever been a smoker? Yes ☐ No ☐

(b) Past / Current smoker? _____

(c) Age you started smoking: _____

(d) Age you quit smoking (for past smokers only): _____

(e) Average number of cigarettes smoked per day: _____

2) Drinking (alcohol)

(a) How many drinks do you usually have per week? _____

3) Body weight

(a) Has your weight fluctuated more than a few kilos in the last 12 months? Yes ☐ No ☐

(b) If 'Yes', approximately how many kilograms? _____

4) Physical activity

(a) What is your current level of physical activity? Active ☐ Inactive ☐ Details:

_____

_____

5) Do you have, or have a family history of any of the following neurological conditions? (Check all/any boxes that apply)

	You	Family		You	Family
Parkinson's		☐	Migraines	☐	☐
Dementia (e.g, Alzheimer's)	☐	☐	Epilepsy	☐	☐
Multiple Sclerosis	☐	☐	Huntington's	☐	☐
Progressive Supranuclear Palsy	☐	☐	Motor Neurone	☐	☐
Cortico-basillar degeneration	☐	☐	Essential Tremor	☐	☐
Stroke or Transient Ischemic Attacks (TIA's)	☐	☐	Other	☐	☐

_____

_____

6) Do you have, or have you had any of the following medical conditions? (Check all/any boxes that apply)

	You	Family		You	Family
Diabetes (Type I or Type II)	☐	☐	Arthritis	☐	☐
Tumour or Cancer affecting the brain	☐	☐	Heart Disease	☐	☐
Other Cancer (please specify below)	☐	☐	Colour Blindness	☐	☐

7) Do you have any other medical conditions? (chronic or serious illness) Yes /No. Details:

_____

_____

_____

8) Have you ever lost consciousness as a result of a head injury Yes ☐ No ☐

How long for? _____

What happened to you? _____

_____

_____

9) Have you ever been diagnosed as suffering from a mental health condition?

Yes ☐ No ☐

If so, was it:

Depression	☐	Anxiety	☐
Schizophrenia	☐	BiPolar Disorder	☐
Personality Disorder	☐	Other _____	☐

When were you diagnosed? _____

What type of treatment were/are you receiving (psychotherapy, medications etc)?_____

_____

_____

DEMOGRAPHIC INFORMATION

(a) Which of the following best describes your ethnic background?
(Check any boxes that apply, or complete the section marked 'Other')

Australian ☐

Australian Aboriginal/Torres Strait Islander ☐

North-Western European ☐

Southern or Eastern European ☐

Asian ☐

African ☐

Other (please specify) ☐ _____

Decline to say ☐

(b) Country of origin

In which country were you born? _____

If you were not born in Australia, in what year did you arrive in Australia? / /

In which country were your parents and grandparents born?

Mother _____ Grandmother _____

Grandfather _____

Father _____ Grandmother _____

Grandfather _____

Decline to say ☐

(c) Is English your first language? Yes ☐ No ☐

If no, at what age did you learn to speak English? _____

How would you rate your English?

Excellent ☐ Very Good ☐ Good ☐ Poor ☐

(d) Are you retired: Yes ☐ No ☐

(e) What is your current occupation? If retired, what was your previous occupation?

_____

(f) How many years of formal education have you completed?

_____

(g) What is your highest level of education? (i.e., year 10, year 11-12, undergraduate degree, postgraduate degree, trade certificate, other)

_____

(h) Impact of Parkinson's on work/employment

I gave up job/retired early	☐
I reduced hours at work	☐
I did not change my hours at work	☐
I was already retired	☐
Other	☐

(i) Impact of Parkinson's upon driving

How would you rate your current driving ability (compared to an average road user)?

Excellent ☐ Better ☐ Neither Better nor Worse ☐ Worse ☐ Much Worse ☐

Has having Parkinson's affected your ability to drive? Yes ☐ No ☐

Please provide further details if appropriate _____

_____

_____

Supplementary Material F

Meta-Memory Questionnaire: Ability Subscale

Name: _____ Date: _____

Memory Mistakes

Below is a list of common memory mistakes that people make. Decide how often you have done each one in the *last two weeks,* then place a check mark in the appropriate column.

	All the time	Often	Sometimes	Rarely	Never
1 Forget to pay a bill on time.					
2 Misplace something you use daily, like your keys or glasses.					
3 Have trouble remembering a telephone number you just looked up.					
4 Not recall the name of someone you just met.					
5 Leave something behind when you meant to bring it with you.					
6 Forget an appointment.					
7 Forget what you were just about to do; for example, walk into a room and forget what you went there to do.					
8 Forget to run an errand.					
9 In conversation, have difficulty coming up with a specific word that you want.					
10 Have trouble remembering details from a newspaper or magazine article you read earlier that day.					
11 Forget to take medication.					
12 Not recall the name of someone you have known for some time.					
13 Forget to pass on a message.					
14 Forget what you were going to say in conversation.					
15 Forget a birthday or anniversary that you used to know well.					
16 Forget a telephone number you use frequently.					
17 Retell a story or joke to the same person because you forgot that you had already told him or her.					
18 Misplace something that you put away a few days ago.					
19 Forget to buy something you intended to buy.					
20 Forget details about a recent conversation.					

Supplementary Material G

Big Five Aspects Scale Questionnaire

Here are a number of characteristics that may or may not describe you.

For example, do you agree or disagree that you make friends easily?

Please tick the box that best indicates the extent to which you agree or disagree with each statement listed below.

Be as honest as possible, but try to rely on your initial feeling and do not think too much about each item.

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1. I seldom feel blue.	☐	☐	☐	☐	☐
2. I am not interested in other people's problems.	☐	☐	☐	☐	☐
3. I carry out my plans.	☐	☐	☐	☐	☐
4. I make friends easily.	☐	☐	☐	☐	☐
5. I am quick to understand things.	☐	☐	☐	☐	☐
6. I get angry easily.	☐	☐	☐	☐	☐
7. I respect authority.	☐	☐	☐	☐	☐
8. I leave my belongings around.	☐	☐	☐	☐	☐
9. I take charge.	☐	☐	☐	☐	☐
10. I enjoy the beauty of nature.	☐	☐	☐	☐	☐
11. I am filled with doubts about things.	☐	☐	☐	☐	☐
12. I feel others' emotions.	☐	☐	☐	☐	☐
13. I waste my time.	☐	☐	☐	☐	☐
14. I am hard to get to know.	☐	☐	☐	☐	☐
15. I have difficulty understanding abstract ideas.	☐	☐	☐	☐	☐
16. I rarely get irritated.	☐	☐	☐	☐	☐
17. I believe that I am better than others.	☐	☐	☐	☐	☐
18. I like order.	☐	☐	☐	☐	☐
19. I have a strong personality.	☐	☐	☐	☐	☐

BFAS-IPIP 1

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
20. I believe in the importance of art.	☐	☐	☐	☐	☐
21. I feel comfortable with myself.	☐	☐	☐	☐	☐
22. I inquire about others' well-being.	☐	☐	☐	☐	☐
23. I find it difficult to get down to work.	☐	☐	☐	☐	☐
24. I keep others at a distance.	☐	☐	☐	☐	☐
25. I can handle a lot of information.	☐	☐	☐	☐	☐
26. I get upset easily.	☐	☐	☐	☐	☐
27. I hate to seem pushy.	☐	☐	☐	☐	☐
28. I keep things tidy.	☐	☐	☐	☐	☐
29. I lack the talent for influencing people.	☐	☐	☐	☐	☐
30. I love to reflect on things.	☐	☐	☐	☐	☐
31. I feel threatened easily.	☐	☐	☐	☐	☐
32. I can't be bothered with others' needs.	☐	☐	☐	☐	☐
33. I mess things up.	☐	☐	☐	☐	☐
34. I reveal little about myself.	☐	☐	☐	☐	☐
35. I like to solve complex problems.	☐	☐	☐	☐	☐
36. I keep my emotions under control.	☐	☐	☐	☐	☐
37. I take advantage of others.	☐	☐	☐	☐	☐
38. I follow a schedule.	☐	☐	☐	☐	☐
39. I know how to captivate people.	☐	☐	☐	☐	☐
40. I get deeply immersed in music.	☐	☐	☐	☐	☐
41. I rarely feel depressed.	☐	☐	☐	☐	☐
42. I sympathize with others' feelings.	☐	☐	☐	☐	☐
43. I finish what I start.	☐	☐	☐	☐	☐

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
44. I warm up quickly to others.	☐	☐	☐	☐	☐
45. I avoid philosophical discussions.	☐	☐	☐	☐	☐
46. I change my mood a lot.	☐	☐	☐	☐	☐
47. I avoid imposing my will on others.	☐	☐	☐	☐	☐
48. I am not bothered by messy people.	☐	☐	☐	☐	☐
49. I wait for others to lead the way.	☐	☐	☐	☐	☐
50. I do not like poetry.	☐	☐	☐	☐	☐
51. I worry about things.	☐	☐	☐	☐	☐
52. I am indifferent to the feelings of others.	☐	☐	☐	☐	☐
53. I don't put my mind on the task at hand.	☐	☐	☐	☐	☐
54. I rarely get caught up in the excitement.	☐	☐	☐	☐	☐
55. I avoid difficult reading material.	☐	☐	☐	☐	☐
56. I rarely lose my composure.	☐	☐	☐	☐	☐
57. I rarely put people under pressure.	☐	☐	☐	☐	☐
58. I want everything to be "just right."	☐	☐	☐	☐	☐
59. I see myself as a good leader.	☐	☐	☐	☐	☐
60. I seldom notice the emotional aspects of paintings and pictures.	☐	☐	☐	☐	☐
61. I am easily discouraged.	☐	☐	☐	☐	☐
62. I take no time for others.	☐	☐	☐	☐	☐
63. I get things done quickly.	☐	☐	☐	☐	☐
64. I am not a very enthusiastic person.	☐	☐	☐	☐	☐
65. I have a rich vocabulary.	☐	☐	☐	☐	☐

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
66. I am a person whose moods go up and down easily.	☐	☐	☐	☐	☐
67. I insult people.	☐	☐	☐	☐	☐
68. I am not bothered by disorder.	☐	☐	☐	☐	☐
69. I can talk others into doing things.	☐	☐	☐	☐	☐
70. I need a creative outlet.	☐	☐	☐	☐	☐
71. I am not embarrassed easily.	☐	☐	☐	☐	☐
72. I take an interest in other people's lives.	☐	☐	☐	☐	☐
73. I always know what I am doing.	☐	☐	☐	☐	☐
74. I show my feelings when I'm happy.	☐	☐	☐	☐	☐
75. I think quickly.	☐	☐	☐	☐	☐
76. I am not easily annoyed.	☐	☐	☐	☐	☐
77. I seek conflict.	☐	☐	☐	☐	☐
78. I dislike routine.	☐	☐	☐	☐	☐
79. I hold back my opinions.	☐	☐	☐	☐	☐
80. I seldom get lost in thought.	☐	☐	☐	☐	☐
81. I become overwhelmed by events.	☐	☐	☐	☐	☐
82. I don't have a soft side.	☐	☐	☐	☐	☐
83. I postpone decisions.	☐	☐	☐	☐	☐
84. I have a lot of fun.	☐	☐	☐	☐	☐
85. I learn things slowly.	☐	☐	☐	☐	☐
86. I get easily agitated.	☐	☐	☐	☐	☐
87. I love a good fight.	☐	☐	☐	☐	☐
88. I see that rules are observed.	☐	☐	☐	☐	☐

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
89. I am the first to act.	☐	☐	☐	☐	☐
90. I seldom daydream.	☐	☐	☐	☐	☐
91. I am afraid of many things.	☐	☐	☐	☐	☐
92. I like to do things for others.	☐	☐	☐	☐	☐
93. I am easily distracted.	☐	☐	☐	☐	☐
94. I laugh a lot.	☐	☐	☐	☐	☐
95. I formulate ideas clearly.	☐	☐	☐	☐	☐
96. I can be stirred up easily.	☐	☐	☐	☐	☐
97. I am out for my own personal gain.	☐	☐	☐	☐	☐
98. I want every detail taken care of.	☐	☐	☐	☐	☐
99. I do not have an assertive personality.	☐	☐	☐	☐	☐
100. I see beauty in things that others might not notice.	☐	☐	☐	☐	☐

Thank you for taking the time to complete this questionnaire.

Your responses are very important to us.

Supplementary Material H

List of measures used in Parkinson's Centre heterogeneity study

Questionnaires:

1. Demographic questionnaire
2. Cambridge Behavioral Inventory (CBI)
3. Depression, Anxiety and Stress Scale (DASS)
4. Geriatric Depression Scale (GDS)
5. State-Trait Anxiety Scale-State Version Y1 (STAI)
6. Meta Memory Questionnaire (MMQ)
7. Big Five Aspects Scale (BFAS)
8. Ways of Coping Questionnaire (WOCQ)
9. Parkinson's Disease Questionnaire (PDQ-39)
10. The Revised Parkinson's Disease Sleep Scale (PDSS-R)
11. Epworth Sleepiness Scale (ESS)
12. Unified Parkinson's Disease Rating Scale (UPDRS) Non-Motor Aspects of Experiences of Daily Living

Measures:

13. Mini-Mental Status Examination (MMSE)
14. Australian National Adult Reading Test (AUSNART)
15. Hopkins Verbal Learning Test-Revised (HLVT-R)
16. Cube Analysis
17. Number Location
18. Star Cancellation Task
19. Line Bisection
20. HLVT-R Delayed recall and recognition
21. California Oral Word Association (COWA-Verbal Fluency)
22. CANTAB-

- Spatial Working Memory (SWM)
- Pattern Recognition Memory (PRM)
- Spatial Recognition Memory (SRM)
- Stockings of Cambridge (SOC)

23. HVLT awareness question
24. Unified Parkinson's Disease Rating Scale (UPDRS) Motor Assessment

Supplementary Material I

SPSS Statistical Analysis Output

Descriptive and Skewness and Kurtosis Statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Age at participation in Cognitive Study 1	98	37	85	64.00	8.971	-.165	.244	.324	.483
SWM Total errors	98	0	87	41.59	20.758	-.182	.244	-.746	.483
MSE_Time1	98	5.00	75.00	50.5504	12.14064	-.946	.244	1.741	.483
Neuroticism_Time1	98	23.00	83.00	52.4884	12.01123	.271	.244	-.558	.483
OPENNESS_Time1	98	47.00	88.00	66.3787	8.54212	.367	.244	-.019	.483
Valid N (listwise)	98								

Zscore Extreme Values

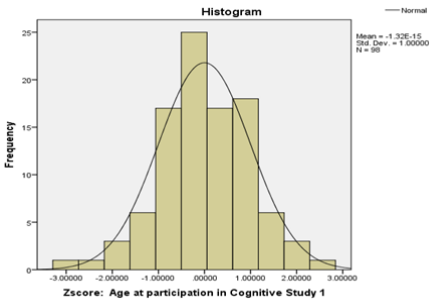
Extreme Values

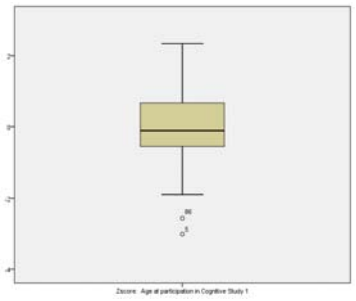
			Case Number	Value
Zscore: Age at participation in Cognitive Study 1	Highest	1	95	2.34094
		2	89	2.22947
		3	30	1.89505
		4	54	1.89505
		5	94	1.67210
	Lowest	1	5	-3.00978
		2	86	-2.56389
		3	70	-1.89505
		4	69	-1.89505
		5	82	-1.67210
Zscore: SWM Total errors	Highest	1	51	2.18748
		2	62	1.80209
		3	95	1.75392
		4	59	1.46487
		5	10	1.41670
	Lowest	1	82	-2.00363
		2	47	-2.00363
		3	19	-2.00363
		4	8	-1.81094
		5	5	-1.71459
Zscore(MSE_Time1)	Highest	1	31	2.01386
		2	71	1.76676
		3	2	1.60202
		4	49	1.43729
		5	63	1.43729
	Lowest	1	20	-3.75190
		2	93	-2.68111
		3	27	-2.59874
		4	69	-2.18690
		5	95	-1.85743[a]
Zscore (Neuroticism_Time1)	Highest	1	93	2.54026
		2	20	2.04072
		3	13	1.97750
		4	26	1.87421
		5	69	1.70770
	Lowest	1	2	-2.45507
		2	87	-1.87228
		3	49	-1.53926
		4	45	-1.45600
		5	47	-1.37275
Zscore (OPENNESS_Time1)	Highest	1	7	2.53115
		2	73	2.53115
		3	88	2.16190
		4	49	2.06288
		5	2	1.82874[b]
	Lowest	1	23	-2.26860
		2	18	-1.80033
		3	97	-1.68327
		4	52	-1.68327
		5	35	-1.68327

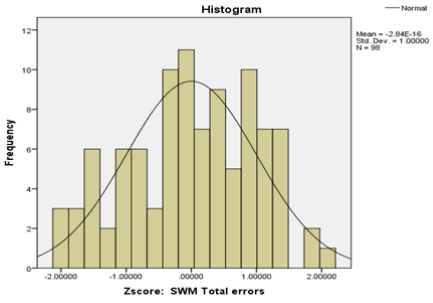
a. Only a partial list of cases with the value -1.85743 are shown in the table of lower extremes.

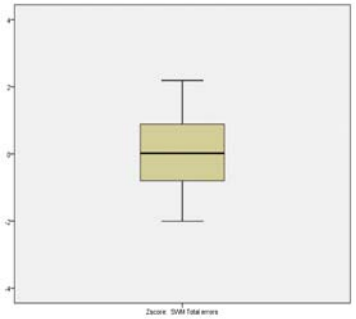
b. Only a partial list of cases with the value 1.82874 are shown in the table of upper extremes.

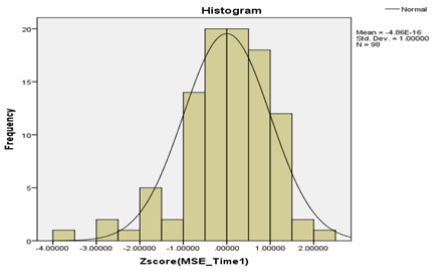
Zscore Frequency Histograms

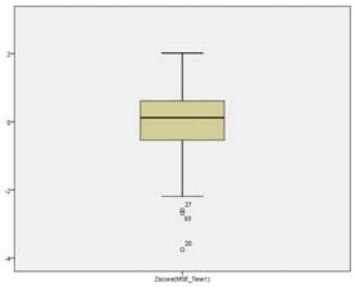


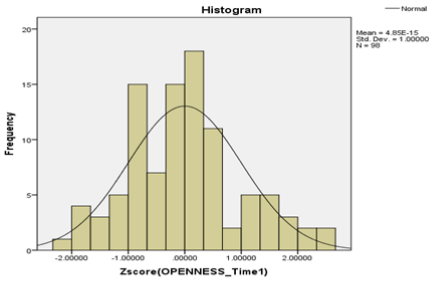


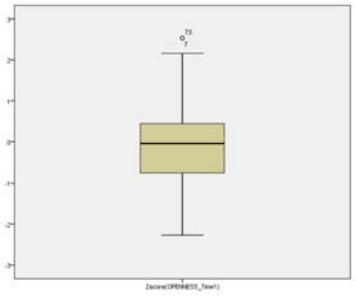


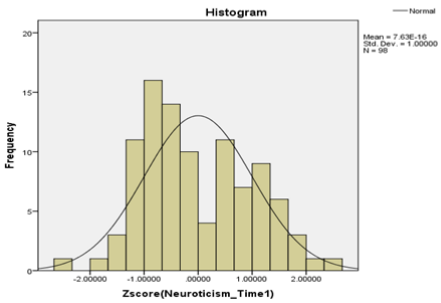


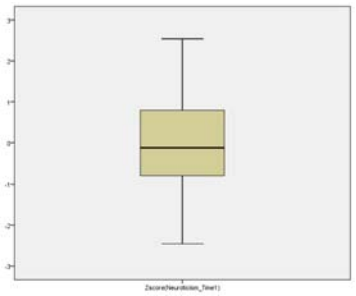










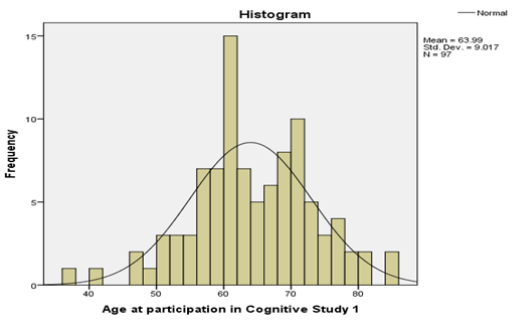


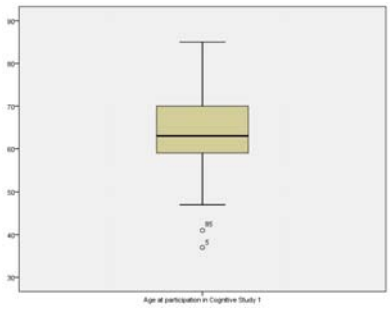
Descriptive Statistics following Outlier Removal

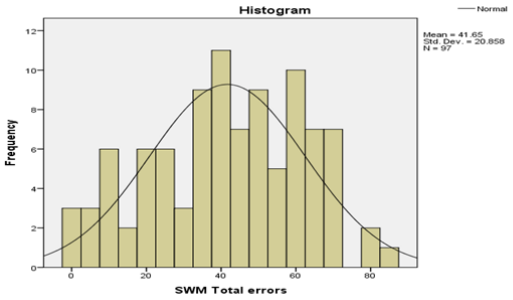
Descriptives

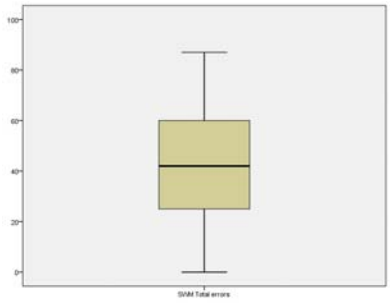
			Statistic	Std. Error
SWM Total errors	Mean		41.65	2.118
	95% Confidence Interval for Mean	Lower Bound	37.45	
		Upper Bound	45.85	
	5% Trimmed Mean		41.86	
	Median		42.00	
	Variance		435.063	
	Std. Deviation		20.858	
	Minimum		0	
	Maximum		87	
	Range		87	
	Interquartile Range		35	
	Skewness		-.190	.245
	Kurtosis		-.765	.485
MSE_Time1	Mean		51.0200	1.14466
	95% Confidence Interval for Mean	Lower Bound	48.7479	
		Upper Bound	53.2921	
	5% Trimmed Mean		51.4701	
	Median		52.0000	
	Variance		127.095	
	Std. Deviation		11.27363	
	Minimum		18.00	
	Maximum		75.00	
	Range		57.00	
	Interquartile Range		13.75	
	Skewness		-.620	.245
	Kurtosis		.621	.485
Neuroticism_Time1	Mean		52.2357	1.19901
	95% Confidence Interval for Mean	Lower Bound	49.8557	
		Upper Bound	54.6157	
	5% Trimmed Mean		52.0713	
	Median		51.0000	
	Variance		139.449	
	Std. Deviation		11.80887	
	Minimum		23.00	
	Maximum		83.00	
	Range		60.00	
	Interquartile Range		18.50	
	Skewness		.258	.245
	Kurtosis		-.536	.485
OPENNESS_Time1	Mean		66.3929	.87171
	95% Confidence Interval for Mean	Lower Bound	64.6625	
		Upper Bound	68.1232	
	5% Trimmed Mean		66.2012	
	Median		66.0000	
	Variance		73.708	
	Std. Deviation		8.58533	
	Minimum		47.00	
	Maximum		88.00	
	Range		41.00	
	Interquartile Range		10.58	
	Skewness		.361	.245
	Kurtosis		-.051	.485
Age at participation in Cognitive Study 1	Mean		63.99	.916
	95% Confidence Interval for Mean	Lower Bound	62.17	
		Upper Bound	65.81	
	5% Trimmed Mean		64.09	
	Median		63.00	
	Variance		81.302	
	Std. Deviation		9.017	
	Minimum		37	
	Maximum		85	
	Range		48	
	Interquartile Range		11	
	Skewness		-.161	.245
	Kurtosis		.290	.485

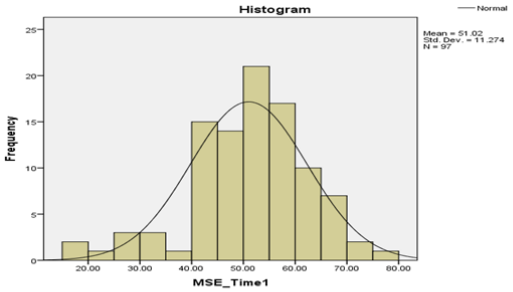
Frequency Histograms and Boxplots following Outlier Removal

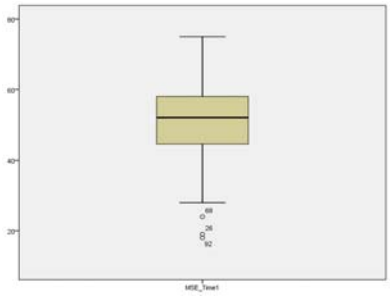


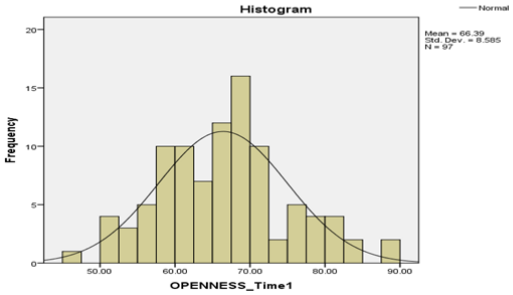


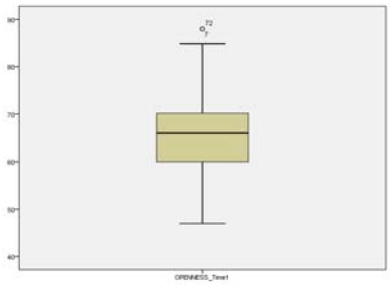


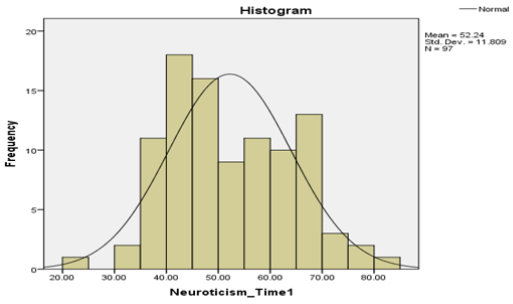


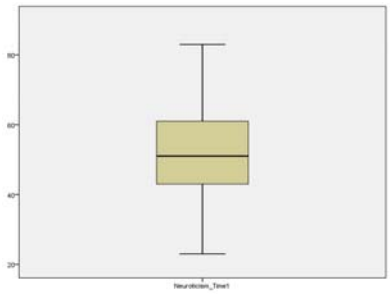












Correlation Matrix for Control, Predictor and Criterion Variables

Correlations

		Age at participation in Cognitive Study 1	Sex	SWM Total errors	MSE_Time1	Neuroticism_ Time1	OPENNESS_ Time1
Age at participation in Cognitive Study 1	Pearson Correlation	1	-.198	.439**	-.075	-.127	-.010
	Sig. (2-tailed)		.052	.000	.465	.214	.926
	N	97	97	97	97	97	97
Sex	Pearson Correlation	-.198	1	-.067	-.072	.104	-.012
	Sig. (2-tailed)	.052		.517	.486	.310	.911
	N	97	97	97	97	97	97
SWM Total errors	Pearson Correlation	.439**	-.067	1	-.142	.057	-.050
	Sig. (2-tailed)	.000	.517		.166	.579	.624
	N	97	97	97	97	97	97
MSE_Time1	Pearson Correlation	-.075	-.072	-.142	1	-.445**	.289**
	Sig. (2-tailed)	.465	.486	.166		.000	.004
	N	97	97	97	97	97	97
Neuroticism_Time1	Pearson Correlation	-.127	.104	.057	-.445**	1	-.341**
	Sig. (2-tailed)	.214	.310	.579	.000		.001
	N	97	97	97	97	97	97
OPENNESS_Time1	Pearson Correlation	-.010	-.012	-.050	.289**	-.341**	1
	Sig. (2-tailed)	.926	.911	.624	.004	.001	
	N	97	97	97	97	97	97

**. Correlation is significant at the 0.01 level (2-tailed).

Moderation Analysis: MSE (Time 1) predicting SWM (Time 2); Openness to Experience moderating the relationship between MSE (Time 1) and SWM (Time 2).

Model Summary[e]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.439[a]	.193	.185	18.835	.193	22.732	1	95	.000
2	.453[b]	.205	.188	18.794	.012	1.410	1	94	.238
3	.453[c]	.205	.180	18.892	.000	.027	1	93	.869
4	.465[d]	.216	.182	18.864	.011	1.281	1	92	.261

a. Predictors: (Constant), Age at participation in Cognitive Study 1

b. Predictors: (Constant), Age at participation in Cognitive Study 1, MSE_Time1

c. Predictors: (Constant), Age at participation in Cognitive Study 1, MSE_Time1, OPENNESS_Time1

d. Predictors: (Constant), Age at participation in Cognitive Study 1, MSE_Time1, OPENNESS_Time1, MSE_x_OPEN_Time1

e. Dependent Variable: SWM Total errors

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8064.430	1	8064.430	22.732	.000[b]
	Residual	33701.652	95	354.754		
	Total	41766.082	96			
2	Regression	8562.649	2	4281.325	12.121	.000[c]
	Residual	33203.433	94	353.228		
	Total	41766.082	96			
3	Regression	8572.444	3	2857.481	8.006	.000[d]
	Residual	33193.638	93	356.921		
	Total	41766.082	96			
4	Regression	9028.231	4	2257.058	6.343	.000[e]
	Residual	32737.851	92	355.846		
	Total	41766.082	96			

a. Dependent Variable: SWM Total errors

b. Predictors: (Constant), Age at participation in Cognitive Study 1

c. Predictors: (Constant), Age at participation in Cognitive Study 1, MSE_Time1

d. Predictors: (Constant), Age at participation in Cognitive Study 1, MSE_Time1, OPENNESS_Time1

e. Predictors: (Constant), Age at participation in Cognitive Study 1, MSE_Time1, OPENNESS_Time1, MSE_x_OPEN_Time1

Coefficients[a]

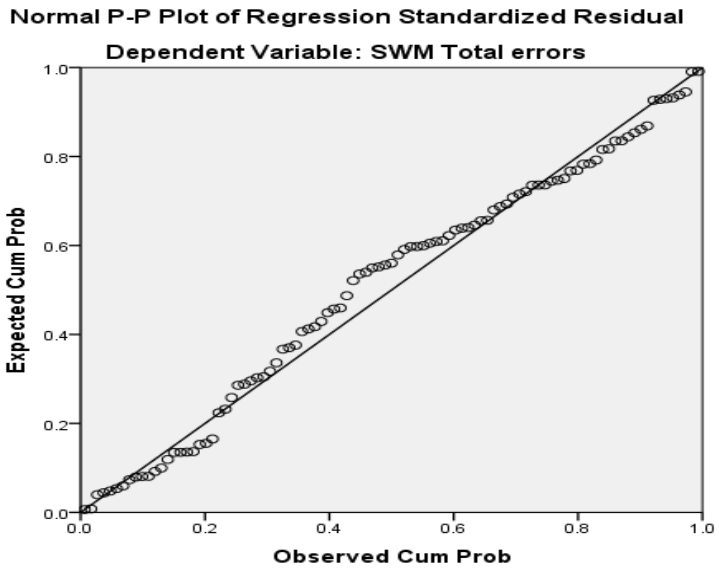
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-23.395	13.776		-1.698	.093	-50.743	3.953					
	Age at participation in Cognitive Study 1	1.016	.213	.439	4.768	.000	.593	1.440	.439	.439	.439	1.000	1.000
2	(Constant)	-11.841	16.841		-.703	.484	-45.278	21.597					
	Age at participation in Cognitive Study 1	.997	.213	.431	4.676	.000	.574	1.421	.439	.434	.430	.994	1.006
	MSE_Time1	-.203	.171	-.110	-1.188	.238	-.541	.136	-.142	-.122	-.109	.994	1.006
3	(Constant)	-9.727	21.199		-.459	.647	-51.824	32.370					
	Age at participation in Cognitive Study 1	.998	.214	.431	4.653	.000	.572	1.424	.439	.435	.430	.994	1.006
	MSE_Time1	-.194	.179	-.105	-1.083	.282	-.550	.162	-.142	-.112	-.100	.911	1.097
	OPENNESS_Time1	-.039	.235	-.016	-.166	.869	-.505	.427	-.050	-.017	-.015	.916	1.091
4	(Constant)	-16.687	22.042		-.757	.451	-60.464	27.091					
	Age at participation in Cognitive Study 1	1.048	.219	.453	4.793	.000	.613	1.482	.439	.447	.442	.954	1.048
	MSE_Time1	-.121	.190	-.066	-.639	.525	-.499	.256	-.142	-.066	-.059	.807	1.239
	OPENNESS_Time1	-.048	.234	-.020	-.205	.838	-.514	.418	-.050	-.021	-.019	.915	1.093
	MSE_x_OPEN_Time1	.025	.022	.113	1.132	.261	-.019	.068	.061	.117	.104	.858	1.166

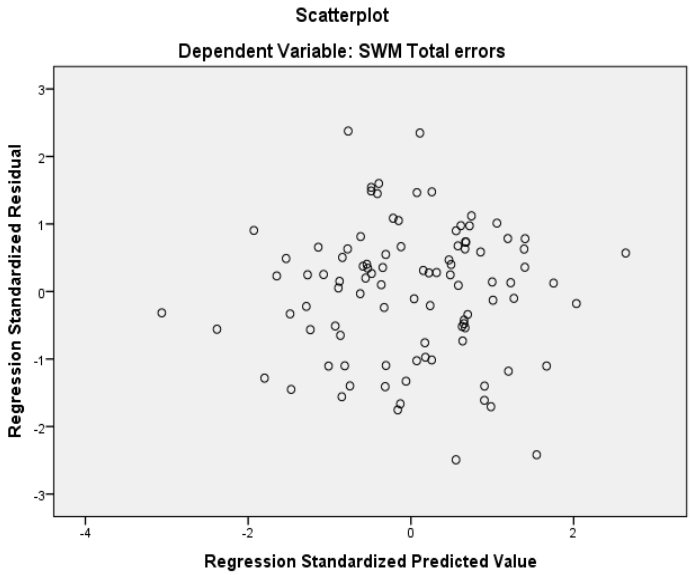
a. Dependent Variable: SWM Total errors

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	11.96	67.24	41.65	9.698	97
Std. Predicted Value	-3.061	2.639	.000	1.000	97
Standard Error of Predicted Value	2.063	9.162	4.011	1.509	97
Adjusted Predicted Value	12.69	65.99	41.75	9.725	97
Residual	-47.018	44.828	.000	18.467	97
Std. Residual	-2.492	2.376	.000	.979	97
Stud. Residual	-2.547	2.410	-.003	1.005	97
Deleted Residual	-49.094	46.092	-.104	19.508	97
Stud. Deleted Residual	-2.627	2.476	-.004	1.016	97
Mahal. Distance	.158	21.657	3.959	4.081	97
Cook's Distance	.000	.158	.012	.024	97
Centered Leverage Value	.002	.226	.041	.043	97

a. Dependent Variable: SWM Total errors


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: SWM Total errors
Expected Cum Prob
Observed Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0


Scatterplot
Dependent Variable: SWM Total errors
Regression Standardized Residual
Regression Standardized Predicted Value
3
2
1
0
-1
-2
-3
-4
-2
0
2

Moderation Analysis: Neuroticism Moderating the Relationship between MSE (Time 1) and SWM (Time 2)

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.439[a]	.193	.185	18.835	.193	22.732	1	95	.000
2	.458[b]	.210	.185	18.834	.017	1.005	2	93	.370
3	.481[c]	.232	.198	18.674	.022	2.595	1	92	.111

a. Predictors: (Constant), Age at participation in Cognitive Study 1

b. Predictors: (Constant), Age at participation in Cognitive Study 1, MSE_Time1, Neuroticism_Time1

c. Predictors: (Constant), Age at participation in Cognitive Study 1, MSE_Time1, Neuroticism_Time1, MSE_x_NEURO_Time1

d. Dependent Variable: SWM Total errors

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8064.430	1	8064.430	22.732	.000[b]
	Residual	33701.652	95	354.754		
	Total	41766.082	96			
2	Regression	8777.501	3	2925.834	8.248	.000[c]
	Residual	32988.582	93	354.716		
	Total	41766.082	96			
3	Regression	9682.580	4	2420.645	6.941	.000[d]
	Residual	32083.502	92	348.734		
	Total	41766.082	96			

a. Dependent Variable: SWM Total errors

b. Predictors: (Constant), Age at participation in Cognitive Study 1

c. Predictors: (Constant), Age at participation in Cognitive Study 1, MSE_Time1, Neuroticism_Time1

d. Predictors: (Constant), Age at participation in Cognitive Study 1, MSE_Time1, Neuroticism_Time1, MSE_x_NEURO_Time1

Coefficients[a]

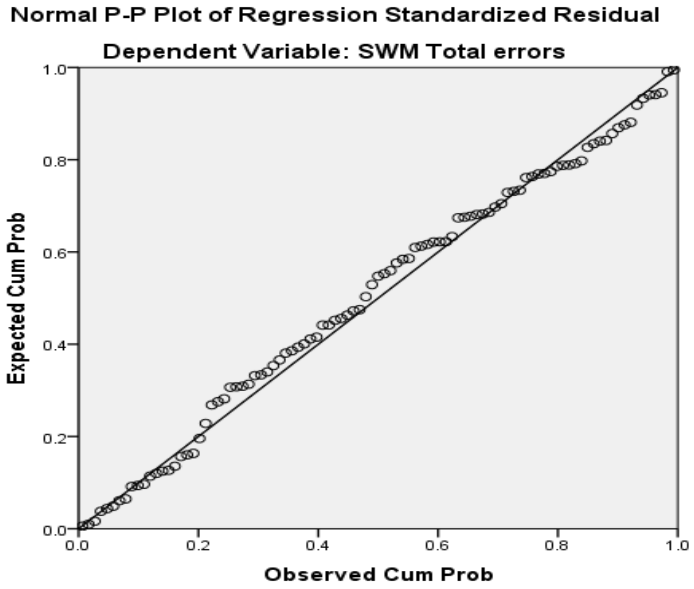
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-23.395	13.776		-1.698	.093	-50.743	3.953					
	Age at participation in Cognitive Study 1	1.016	.213	.439	4.768	.000	.593	1.440	.439	.439	.439	1.000	1.000
2	(Constant)	-24.817	23.724		-1.046	.298	-71.928	22.293					
	Age at participation in Cognitive Study 1	1.028	.217	.444	4.730	.000	.596	1.460	.439	.440	.436	.962	1.039
	MSE_Time1	-.134	.193	-.072	-.695	.489	-.516	.249	-.142	-.072	-.064	.784	1.275
	Neuroticism_Time1	.144	.185	.081	.778	.438	-.223	.511	.057	.080	.072	.776	1.289
3	(Constant)	-31.877	23.928		-1.332	.186	-79.400	15.645					
	Age at participation in Cognitive Study 1	1.080	.218	.467	4.956	.000	.647	1.513	.439	.459	.453	.941	1.063
	MSE_Time1	-.059	.197	-.032	-.299	.766	-.449	.332	-.142	-.031	-.027	.740	1.351
	Neuroticism_Time1	.120	.184	.068	.654	.515	-.245	.485	.057	.068	.060	.771	1.297
	MSE_x_NEURO_Time1	-.019	.012	-.156	-1.611	.111	-.043	.005	-.117	-.166	-.147	.887	1.127

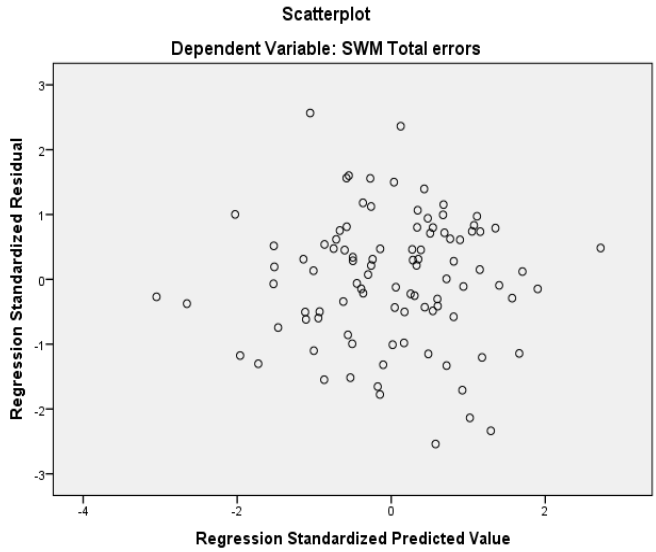
a. Dependent Variable: SWM Total errors

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	11.04	68.96	41.65	10.043	97
Std. Predicted Value	-3.047	2.719	.000	1.000	97
Standard Error of Predicted Value	2.091	11.569	3.946	1.558	97
Adjusted Predicted Value	11.68	76.76	41.95	10.552	97
Residual	-47.433	47.924	.000	18.281	97
Std. Residual	-2.540	2.566	.000	.979	97
Stud. Residual	-2.722	2.610	-.007	1.013	97
Deleted Residual	-64.760	49.559	-.299	19.729	97
Stud. Deleted Residual	-2.823	2.697	-.009	1.026	97
Mahal. Distance	.214	35.855	3.959	4.818	97
Cook's Distance	.000	.923	.018	.094	97
Centered Leverage Value	.002	.373	.041	.050	97

a. Dependent Variable: SWM Total errors


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: SWM Total errors
Expected Cum Prob
Observed Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0


Scatterplot
Dependent Variable: SWM Total errors
Regression Standardized Residual
Regression Standardized Predicted Value
-4
-2
0
2
-3
-2
-1
0
1
2
3

Supplementary Material J

Extended Results

Data Screening

Prior to conducting the analysis, the data (Time 1: *N*=247, Time 2: *N*=116) was visually inspected for data entry errors and a descriptive analysis was conducted to identify any out of range data. Several data entry mistakes were identified and were cross referenced with the original data file at ParkC and corrected. Eleven participants were misdiagnosed with Parkinson's and were excluded from the study. Seven participants had experienced a stroke or loss of consciousness for longer than 20 minutes and were also excluded. Eleven participants were excluded for scoring >24 on the MMSE. A further 114 participants were removed from Time 1 as they had not yet participated in Time 2.

A missing values analysis was conducted between the control variables, the MMQ-Ability Subscale, BFAS Openness and Neuroticism Subscales, and SWM Total Errors. The missing values analysis produced a non-significant Little's MCAR (p=.599). Six participants had missing data on at least one full measure and were removed from the study. Missing values were replaced for the MMQ-Ability, BFAS Openness and Neuroticism measures using Expectation Maximisation as recommended by Tabachnick and Fidell (2013). There was no missing data for age and gender. A repeat descriptive analysis was conducted on the data (*N*=98) following data corrections and deletions.

Outliers

Visual inspection of the boxplots and skewness and kurtosis statistics supported normal distribution of the data. However, several influential but not extreme univariate outliers were identified on the variables of age, MMQ-Ability and BFAS Openness. One case was removed as the score was >3.29 standard deviations from the mean on the MMQ-Ability questionnaire. The remaining outliers were <3.29 standard deviations from the mean, and were therefore considered not influential and were retained in the analysis and left untransformed (Tabachnick & Fidell, 2013). Observing the trimmed mean also supports the minimal impact of the outliers on the overall mean if the outliers were omitted.

Multivariate outliers were detected by examining the statistical test of Mahalanobis Distance. Three cases had Mahalanobis values exceeding the critical chi-square for four degrees of freedom (x^2=18.467, α=.001). These cases were cross referenced with Cook's values which reported scores of less than one and suggested that the six cases were not influential enough to impact on the regression model. The three cases were retained in the analysis (*N*=97).

Testing for Moderation

Assumption testing. Prior to testing the moderation, the data was assessed against the assumptions for multiple regression which include (i) adequate cases to predictor ratio, (ii) normality, linearity and homoscedasticity and (iii) multicollinearity. To produce a reliable regression, Tabachnick and Fidell (2013) suggest that N should be 50 + (8 x number of predictors) to detect a medium effect size. In this study, 97 participants is an adequate sample size to test both regression models (50 + 32 = 82). The assumption of normality, linearity and homoscedasticity was assessed by visual inspection of the normal P-P plot of regression standardised residuals and by the scatterplot of standardised residuals against standardised predicted values. In both regressions the residuals appeared normally distributed, clustering close to the diagonal in the normal P-P plot. Observing the scatterplots revealed the absence of any clear pattern of data spread, and therefore normality, linearity and homoscedasticity was not violated. The assumption of multicollinearity was examined using Tolerance and VIF statistics. Multicollinearity was not a problem as no tolerance values were >0.1, and all VIF statistics were <10 (Allen & Bennett, 2012).

References

Allen, P., & Bennett, K. (2012). *SPSS Statistics: A Practical Guide Version 20*. Victoria, Australia: Cengage Learning Pty Limited

Tabachnick, B., & Fidell, L. (2013). *Using Multivariate Statistics* (6th ed.). New Jersey, USA: Pearson Education

Supplementary Material K

Statistical Consultation Advice

STATISTICAL CONSULTATION FOR HONOURS STUDENTS 2012

Research Question:

Is there a relationship between memory self-efficacy and spatial working memory in Parkinson's disease, and does this relationship change with varying levels of openness to experience and neuroticism?

Hypotheses:

H1: After controlling for age and gender, memory self-efficacy will significantly predict spatial working memory.

H2: Openness to experience will significantly change the relationship between memory self-efficacy and spatial working memory in Parkinson's disease.

H3: Neuroticism will significantly change the relationship between memory self-efficacy and spatial working memory in Parkinson's disease.

Interaction	**Main effect 2**	**Main effect 1 (H1)**	**Controls**	**DV**
O x M	Openness to experience	Memory self-efficacy	Age, gender	Spatial working memory
	N x M	Memory self-efficacy Neuroticism	Age, gender	Spatial working memory

Wave 1: 229

Sample size required based on Power Analysis:

Minimum of 114 participants, using G*Power.

Sampling strategy:

A convenience sample of self-referred people with diagnosed idiopathic PD, were recruited to a longitudinal research project that is being conducted by the Parkinson's Centre (ParkC), at Edith Cowan University. Participants were recruited through local and PWA advertising. The participants are male and female and of any age.

Inclusion in the study is based on a PD diagnosis according to the UK Brain Bank Clinical Diagnostic Criteria. The Mini-Mental State Exam was used as a cognitive screening measure, with participants scoring below 24 excluded

Measures (include number of factors and alpha reliability where applicable)

Cognitive and motor heterogeneity in idiopathic Parkinson's medical history and demographic questionnaire

Used to collect age and gender data for use as control variables

Meta-memory Questionnaire (MMQ)

Only the ability subscale will be used

The ability subscale consists of 20 questions, and is scored on a 5-point Likert scale (0-4)

Higher scores on the ability subscale (total score of 80), indicate less perceived memory mistakes, while lower scores indicate higher memory mistakes

Ability Subscale (α=.93, *r*=.86)

Big Five Aspects Scale (BFAS)

Only the domains of openness to experience (intellect and openness facets) and neuroticism (withdrawal and voltality) will be used

Both domains consists of 20 items and is scored on a 5-point Likert scale (1-5)

Higher scores in an individual domain indicate higher trait characteristics.

Openness to experience (α=.85)

Neuroticism (α=.89)

Spatial Working Memory (CANTAB™)

This task is measured using search errors (selecting boxes that are empty and revisiting a square where a token has already been found)

The higher number of search errors indicates a lower score of spatial working memory

Planned Analyses

Screen for univariate and multivariate outliers and assessed using Maximum Mahalanobis Distance and Cook's Distance. Missing Data Analysis will be conducted, with expectation maximization to replace missing values. The assumption of normality, linearity and homoscedasticity of residuals will be assessed using the probability plot of standardised residuals. The assumption of multicollinearity will also be assessed using Tolerance and VIF statistics.

2x hierarchical multiple regressions

First regression: MSE and Openness require centring (grand mean centring) to create interaction term. At step one, enter control variables. At step two, enter MSE and openness (main effects). At step three enter the interaction term (centred MSE x centred openness). The output will be used to evaluate if there is a significant relationship between MSE and spatial working memory, after controlling for age and gender (H1), and if openness has significantly changed this relationship (H2).

Second regression: MSE and neuroticism require centring (grand mean centring) to create interaction term. At step one, enter control variables. At step two, enter MSE and neuroticism (main effects). At step three enter the interaction term (centred MSE x centred neuroticism). The output will be used to evaluate if neuroticism has significantly changed the relationship between MSE and spatial working memory (H3).

Specific Questions for Statistical Consultant.

Can the output in the first regression be used to address H1, using main effects? Or should I conduct a separate analysis to address H1?

Can I enter main effects on one step or should they be entered separately?

TO BE COMPLETED BY STATISTICAL ADVISOR

□ **No changes required**

□ **The following changes are required:**

✓**The following comments should be taken on board**

Moderated regression models

	DV	Step 1 (Controls)	Step 2	Step 3	Step 4
Model 1 (M1)	Spatial working memory	Age Gender	Memory self-efficacy (MSE)	Openness to experience (OtE)	MSE x OtE
Model (M2)	Spatial working memory	Age Gender	Memory self-efficacy (MSE) Neuroticism (N)	MSE x N	

1: If a control variable is not significantly correlated with ***the*** DVs, then drop it from the regression model.

The moderated regression models depicted above assume that the four scales (MMQ-Ab, BFAS-Op, BFAS_N, and CANTAB) can be interpreted as uni-factorial measures; in which case their total scores can be used to represent their respective constructs (memory self-efficacy, openness to experience, neuroticism, and spatial working memory). The psychometric properties of *established* scales will have been evaluated in previous studies. You merely need to review these studies to determine the dimensionality of the scale. For *new* scales, or established scales that have been *modified* in some way, you'll need to conduct a confirmatory factor analysis (CFA) to show that the inter-item correlations in your data can be adequately explained in terms of a one-factor solution. Multi-factorial scales can be incorporated into the moderated regression model, but they'll increase the complexity of the model.

Hypotheses

After controlling for age and gender:

H1: Memory self-efficacy will significantly predict spatial working memory.

H2: Openness to experience will moderate the relationship between memory self-efficacy and spatial working memory.

H3: Neuroticism will moderate the relationship between memory self-efficacy and spatial working memory.

Hypothesis testing

H1 predicts a significant regression coefficient on Step 2 of M1 for MSE. H2 predicts a significant regression coefficient on Step 4 of M1 for MSE x OtE. H3 H2 predicts a significant regression coefficient on Step 3 of M2 for MSE x N. Each of the three regression coefficients will have a corresponding partial correlation; effect sizes can be derived by squaring these values.

Assumptions

For each regression analyses, you'll need to test the three regression assumptions of linearity, homoscedasticity, & normality. The scatterplot of the standardised Studentised residuals against standardised predicted values can be examined for violations of these assumptions (see Tabachnick & Fidell, 2001, *p*. 119). In addition, the Cook's Distance statistic will identify influential points (including univariate and multidimensional outliers). Finally, tolerance values for each predictor can be examined for evidence of multicolinearity.

Sample size (assuming a power of .8, an alpha of .05)

If you have a sufficient number of participants to detect the Step 4 two-way interaction, then you'll have a sufficient number of participants to detect all of the lower order effects. If the two-way interaction is 'small' (f^2= .02), then it'll take 395 participants to detect it; if the two-way interaction is 'moderate' (f^2= .15), then it'll take 55 participants to detect it; if the two-way interaction is 'large' (f^2 = .35), then it'll take 25 participants to detect it. Two-way interactions are generally small to moderate (f^2 = .09). For your regression models, it'll take 90 participants to detect a small to moderate two-way interaction.

Note: This advice has been updated (23/10/2013) and information on updates can be provided by Dr Robert Kane.