The effect of dance and exercise to music on mood in those with Parkinson's disease

Thesis submitted for the partial fulfilment of the requirements of the

University of Hertfordshire for the Degree of

'Doctor of Philosophy'

by

Amelia Hall

February 2016

This work was carried out under the supervision of:

Dr Peter Lovatt

Dr Lucy Annett

Abstract

The aim of this thesis was to investigate the effect of dance and exercise to music on mood in those with Parkinson's disease (PD). A series of five studies were conducted in order to explore whether there are physical and psychological benefits of dance and exercise to music for those with PD. This programme of research collected data in a variety of ways, over a number of weeks (study one – 10 weeks), through survey data (study two) and in peoples own homes (study three, four and five). These studies have focused on the effect of these activities on mood and as the programme of research developed, the role of socialisation became a key factor. These studies have concluded that mood is significantly improved following dance and movement to music, but that this may be moderated by social interaction. Mood effects observed during a social dance class initially appeared to be comparable to 30 minutes of exercise to music at home. This suggests that music and movement without the social aspect of a class could also evoke an improvement in mood. After further investigation, however, it appeared that mood may have been affected by the presence of the researcher as a social factor. Overall, this programme of research has suggested that dance and music to movement is a beneficial form of activity but that the social aspect of this is imperative to have an effect on mood.

Table of Contents

Acknowledgements

Index of Figures

Index of Tables

Glossary of terms

PD	Parkinson's disease
PUK	Parkinson's UK
SMA	Supplementary Motor Area
PMA	Pre Motor Area
PET	Positron Emission Tomography
GP	Global Pallidus
SN	Substantia Nigra
MPTP	1-methyl-4-phenyl- 1,2,3,6-tetrahydropyridine
6OHDA	6-hydroxydopamine
SMS	Sensorimotor Synchronization
RAS	Rhythmic Auditory Stimulation
METS	Level of metabolic equivalent
6MWT	6 Minute Walk Test
BBS	Berg Balance Scale
PDQ-39	Parkinson's disease quality of life scale – 39 items
FOG	Freezing of Gait
TUG	Timed Up and Go test
Dual TUG	Dual Timed Up and Go test
POMS	Profile of Mood States
BRUMS	Brunel University Mood Scale
PAR-Q	Physical Activity Readiness Questionnaire
FES	Falls Efficacy Scale
UPDRS	Unified Parkinson's Disease Rating Scale
MDS-UPDRS	Movement Disorders sociery – Unified Parkinson's Disease Rating Scale
SeTa	Semi Tandem Test
9HPT	9 Hole Peg Test
AUT	Alternative Uses Test
ATTA	Abbreviated Torrance Task for Adults
MRT	Mental Rotations Task
LDT	Lexical Decision Task
ABC	Activities- specific Balance Confidence Scale
MMSE	Mini Mental State Examination

Chapter 1: Overview of the thesis

1.1 Motivation

Exercise has been found to have significant improvements on the symptoms of PD (Goodwin, Richards, Taylor, Taylor, & Campbell, 2008). Exercise is widely encouraged for those with Parkinson's disease (PD), with Parkinson's UK offering DVD and leaflet information for people to participate in. More recently, research has suggested that dance may be an alternative form of exercise that may have beneficial effects for a number of outcomes in PD. For example, this limited pool of research suggested that dance may be more beneficial than exercise (Hackney, Kantrovic, Levin & Earhart, 2007; Hackney, Kantrovic & Earhart, 2007) for balance and mobility.

At the start of the PhD, there were seven experimental papers published investigating the effect of dance on the symptoms of PD. These papers tended to explore the effect of tango on a number of outcome measures (Hackney & Earhart, 2009abcd), there were however investigations into contact improvisation and modern dance (Batson, 2010; Marchant, Sylvester & Earhart, 2010). These studies suggested that dance may be beneficial for balance and mobility, however there was little research at this point investigating psychological changes that may be occurring following dance.

This limited research suggested that dance may have some physical improvements for those with PD, but raised many questions as to the benefit, if any, on non motor symptoms of the disease. The research described in this thesis aims to investigate the effect of dance and exercise to music and physical, psychological and cognitive outcomes in those with PD. This thesis will investigate whether dance and exercise can improve psychological outcomes, both in a group and home based setting.

Chapter 2: Literature Review

2.1 PD and the Brain

PD is a progressive neurological condition that affects approximately 127 000 people in the UK (Parkinson's UK). The incidence of PD increases with age, with 17.4 of 100 000 people aged between 50 and 59 developing the disease, compared with 93.1 of 100 000 of people aged between 70 and 79 (Lees, Hardy and Revesz, 2009). PD is heterogeneous and therefore symptoms vary widely between people. The four key characteristic symptoms of PD are, tremor, rigidity, postural instability and slowness of movement (bradykinesia). The majority of those with PD will develop tremor at some stage, with approximately 70% showing signs of tremor at diagnosis. This number increases as the disease advances, with Hornykiewicz (1966) showing that levels of dopamine had dropped to less than 10% in a PD brain after death. Bradykinesia is one of the more common symptoms at the early stages of PD. This concerns slowness in movements such as initiation of walking. This slowness of movement can also occur in facial muscles, causing problems in communication (Lees et al., 2009). There are a number of other motor symptoms that affect some suffers of PD, some of these include freezing and dizziness leading to falls. There are also many non-motor symptoms that are common in PD such as bladder and bowel complications and pain, depression and anxiety. Cognitive decline also becomes more likely as the disease progresses, with approximately 80% of those with PD developing dementia (Aarsland, Andersen, Larsen, Lolk, & Kragh-Sørensen, 2003).

Before discussing the specific details for why dopamine neurones die and the effect it has on a PD brain, it is important to discuss how movement is planned and executed in a healthy brain.

An area of the brain involved in movement control is the motor cortex. The motor cortex is split into different areas namely the primary motor cortex, supplementary motor cortex and premotor cortex. The motor cortex receives information to initiate movement from the frontal, temporal and parietal lobes

which become activated. These lobes give the motor cortex information about the type of action that should be executed; this includes visual cues, memories and goal of the movement. The cues allow the motor cortex to plan the appropriate movement in the supplementary motor area (SMA) and premotor area (PMA), these then feed into the motor cortex.

In addition, there are two further systems in which movements are controlled in a healthy brain. These include both the basal ganglia and cerebellar loops. The basal ganglia are a group of structures in the forebrain that are involved in action selection; these include the caudate, putamen and global pallidus. The basal ganglia receive information from the cerebral cortex, process it and then through the thalamus, then return it to the motor cortex. It may be that the basal ganglia are involved in the decision making for the type of action that will be used.

Figure 2.1. shows the circuits in cortico-striatal circuits within the brain. The striatum and subthalamic nucleus passes input through the basal ganglia and the global pallidus (GPi) and substantia nigra (SN) are the main outputs. Circuits below show the brain areas that do not only control movement, but also non motor systems such as cognition and emotion (Jahanshahi, Obeso, Rothwell & Obeso, 2015).
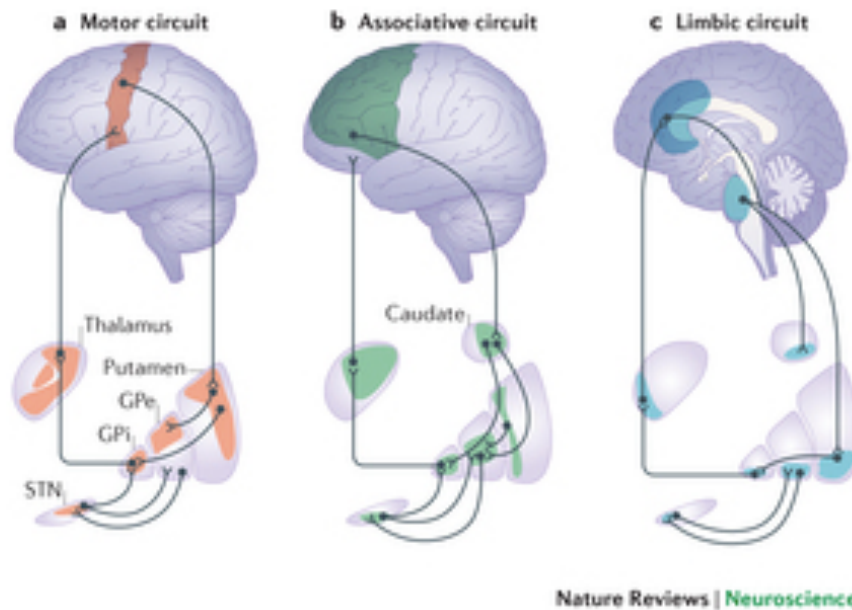
Figure 2.1. Motor, cognitive and emotional cortico-striatal circuits (Jahanshahi et al. 2015)

The striatum and both the motor and sensory cortex work together to initiate the correct and coordinated movements. The intended movement is relayed to the cerebellum that adds additional information to that movement, namely the timing and duration of that movement. The cerebellum times the specific movements such that fluid movements can take place (Robinson, 1995).

Finally, the execution of movement is conducted using information from the basal ganglia and cerebellum. These connect various areas of the cortex to the SMA and PMA. The primary motor cortex is where signals are generated to execute movement. The neurones within the PMA send signals down to the spinal cord through motor neurones. These neurones send messages through muscles in order to facilitate co-ordinated movements.

In order for these processes to be regulated, the neurotransmitter dopamine is required. This neurotransmitter plays a crucial role not only in controlling movement, but regulation of hormonal release and reward motivated (reinforcement) behaviour. The neurotransmitter dopamine is produced in the nerve terminals, mainly in the striatum and cell bodies that are located in the

substantia nigra and ventral tegmental area in the mid-brain. Variations in the levels of dopamine have a marked effect on movement. High levels of dopamine (induced by drug ingestion, such as amphetamines) increase agitated movement. Low levels of dopamine lead to slowness of movement and is a characteristic of PD (Ehringer & Hornykiewicz, 1960).

The symptoms of PD occur when there is a shortage of dopamine in the brain. This loss of dopamine has a significant impact on the basal ganglia. As discussed previously, the basal ganglia and cerebellum perform an important role in keeping motor responses smooth and consistent. Notably the putamen and caudate make up the striatum within the ganglia. The dopaminergic pathway between the subtantia nigra and striatum is disrupted in PD due to the loss of the dopaminergic neurotransmitter, which in turn has an effect on the ability to control motor functioning. When the striatum isn't adequately stimulated, the basal ganglia become either under or over stimulated. Changes in anatomy in a PD brain are not easily visible, although PET scans can measure dopamine activity, Figure 2.2 shows the change in dopamine availability after developing PD.
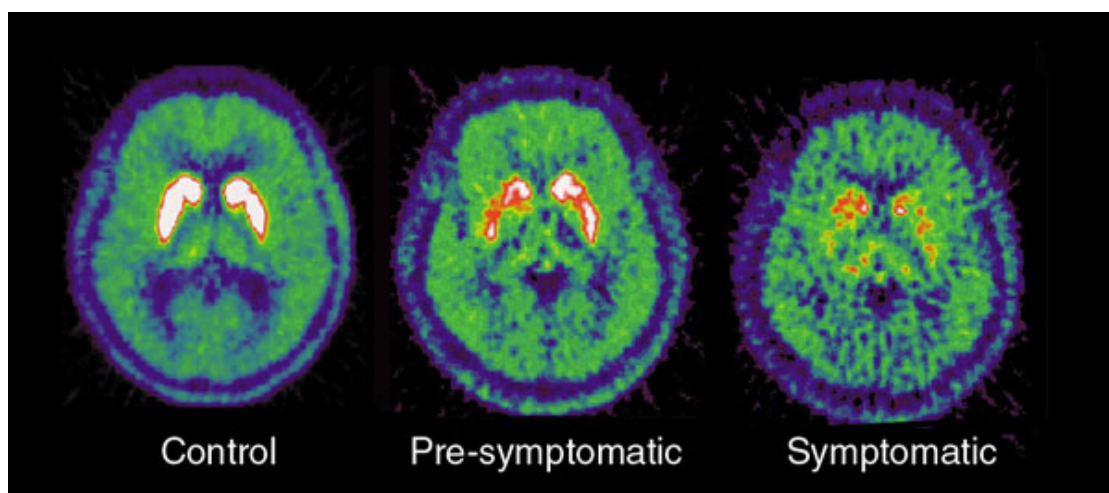
Figure 2.2 PET scan showing the dopamine loss in PD (Dunnett & Bjorkland, 1999).

It is clear to see dopamine loss in a symptomatic case compared with control, and also intermediate dopamine loss in the pre-symptomatic case in Figure 2.2. The white areas on the PET scan denote uptake of Flurodopa by the striatum. The horizontal sections show levels of dopamine in a healthy control, a twin with symptomatic PD and the twin with no symptoms at the time of the scan that went on to develop PD.

In PD, dopamine levels drop due to the degeneration of around 60% of the dopaminergic neurones within the substantia nigra (Gao & Hong, 2011). Although the brain is able to compensate for the low levels of dopamine by boosting sensitivity in the striatum, this can only compensate while there is more than 30% of the cells remaining. When dopamine levels become too low for the post-synaptic compensatory mechanism, the symptoms of PD begin to appear. It has been suggested that dopaminergic cell loss begins at least five years before any symptoms present (Halliday , Lees & Stern, 2011). It is still unknown what causes the cell death in the substantia nigra, although there is evidence to suggest that there may be genetic (Piccini et al. 1999) and environmental factors (Ascherio et al. 2006; Corrigan Weinberg, Shore, Daniel & Mann, 2000). For between 5 and 20% of those with PD, there is a hereditary basis but for all others, there is no known cause (Gao & Hong, 2011).

Those with PD also have a build up of the protein alpha-synuclein which is a component of Lewy bodies within neurones. Where these Lewy bodies are placed tend to have an effect on symptoms of the disease. Braak (Braak & Tredici, 2009) staging (see appendix A) suggests that individuals may have Lewy bodies accumulating before they have any symptoms. As the disease progressses and neurodegeneration reaches the substantia nigra and basal ganglia, dopaminergic neurones are lost. This is when the motor symptoms of PD begin to appear. This can be seen in Figure 2.3
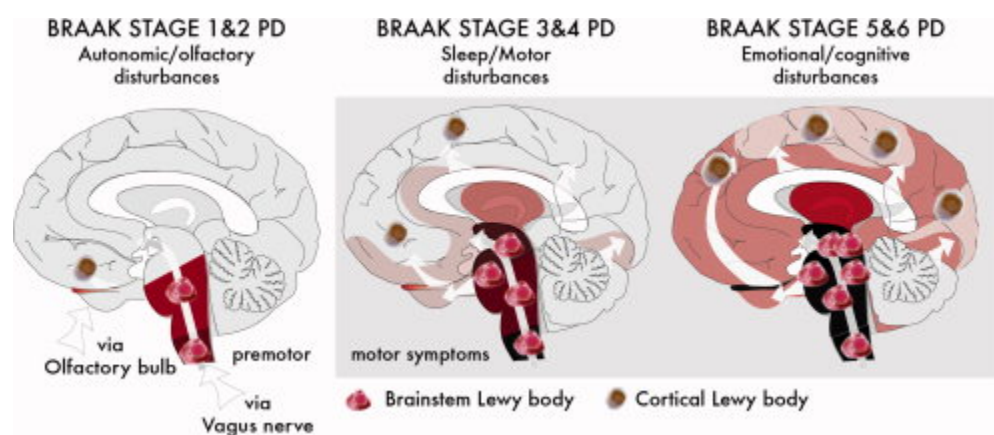
Figure. 2.3 Pictorial representation of the spread of Lewy bodies through as disease progresses, Braak staging (Halliday et al, 2011)

It is thought that Lewy bodies spread through the brain from contact between cells, beginning in the periphery then moving through the olfactory system, causing deficits such as loss of smell. The Lewy bodies then spread through the brainstem which causes motor and sleep problems, which then progress into the limbic system causing emotional symptoms and finally cognitive impairment as the pathology reaches the cortex.

There are a number of medications used to treat PD. Although there is no cure, medications are used to reduce the severity of symptoms. As people with PD present varied symptoms, a number of medications can be used to treat the condition. Medications affect symptoms differently and can be used to target a particular problem caused by the disease. The majority of medications used to treat PD are dopaminergic, either by L-Dopa which is used to boost endogenous dopamine or dopamine agonists that stimulate dopamine receptors.   A comprehensive explanation of the medications used to treat PD can be seen in appendix B.

2.2 Exercise for PD

Although medications are used to treat the symptoms of PD, those with this disease have often benefitted from complementary therapies. There is a wealth of research suggesting that exercise may be beneficial for the symptoms of PD, and more recently musical therapies such as Rhythmic Auditory Stimulation,

dance and singing have been suggesting to be a useful tool alongside traditional medications.

Previous research has suggested that exercise may be beneficial for those with PD.Exercise has been used as an aid to treatment in PD, such as treadmill training (Herman, Giladi, & Hausdorff, 2009). Parkinsons UK advise exercise as a therapy to help strengthen muscles, maintain movement and improve mobility as well as reducing anxiety and feelings of depression. PD and exercise classes have been a common feature of local support groups, with exercise leaflets and advice as well as a number of exercise classes being offered in local communities.

There has been a wealth of previous research that has suggested exercise may be beneficial for the symptoms of PD (Goodwin, Richards, Taylor, Taylor, & Campbell, 2008). It is thought that benefits of exercise may be twofold, including management of symptoms and potential neuroprotective effects on the brain.

Neuroprotection can be described as the protection of neurons in the brain. In a disease such as PD, neuroprotection refers to slowing down the disease progression. Hirsch and Farley (2006) suggested that exercise may have a neuroprotective effect on those with PD. Animal models of PD have been used to investigate the link between exercise and neuroprotection. Fisher et al (2013) explored the neuroprotective effects of treadmill training in 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP) treated mice (dopamine depleted) three times a week for eight weeks. Following the exercise, there were no changes in dopamine levels, but there was a increase in neurotransmission of dopamine and the dopamine receptor DA-D$_2$R BP. The authors suggest changes in dopamine signaling may have been caused by the exercise intervention, showing a neuroprotective effect of exercise. However, it has been argued these findings show exercise can improve behavioral compensation rather than protecting dopamine neurons (Gerecke, Jiao, Pani, Pagala, & Smeyne, 2010), such that there is an upregulation of dopamine receptors (which may be temporary) rather than a long term change. Neuroprotection would be the progression of PD slowing due to the slowing down of neuronal loss.

Other animal models have been used to investigate neuroprotection in models of PD (Fisher et al., 2013; Gerecke et al. 2010; Tillerson, Cohen, Philhower, Miller, Zigmond, Schallert. 2001; Zigmond & Smeyne, 2014). These studies have investigated both the 6-hydroxydopamine (6OHDA) rat models and MPTP treated mice. Gerecke et al. (2010) showed mice exercising with a wheel for three months before MPTP lesions, showed higher levels of dopamine neurones than those with restricted access to exercise. These findings suggested that exercise may have a potentially protective effect on dopamine neurones in a toxin model of PD.

Studies using the 6OHDA models in rats have found evidence of exercise dependent neuroprotection of dopamine neurons. Tajiri, et al. (2010) investigated whether exercise training had a neuropotective effect on rats after being injected with the 6OHDA PD model. This study required one group of rats to run on a treadmill for 30mins per day every day for four weeks, 24 hours after the 6OHDA lesion. The other group of rats did not exercise. The study found that after four weeks, the rats in the exercise group had significantly better behavioral recovery than the non-exercise group. Remaining dopaminergic fibres in the substantia nigra and striatum were shown to be significantly greater in the exercise group following the study.

These findings suggest that exercise may have beneficial effects for those with PD, there may be a non-dopaminergic mechanism compensating for the lack of dopamine available or there may be a true neuroprotective effect of exercise. Findings from these studies are limited but suggest that exercise has positive effects in protecting dopamine transmission in PD. As there have been no human studies to investigate this, it is difficult to conclude that exercise has a neuroprotective effect on PD. Animal models of PD recreate the progression of PD by using a neurotoxin. These toxins may or may not have the same mechanistic changes that result in cell death in PD. Exercise has been seen to have an effect on the progression of the neurotoxin, but this may not replicate in humans with the disease.

Exercise has also been shown to have positive effects on the symptoms of PD. Research has found that exercise may have a beneficial effect on balance, motor problems, gait and quality of life in those with PD (Baatilee et al., 2008 and Allen Sherrington, Paul and Canning, 2011). Yusefi, Tadibi, Khoei, and Montazeri (2009) investigated quality of life in those with PD following a 10-week exercise programme. Participants in the experimental group completed four sessions of exercise for 10 weeks, compared with a control group not completing any activity. Quality of life was significantly improved following the intervention for all measures except emotional wellbeing, this was also seen for participants perception of activities of daily living. No change was seen for the control group. This study suggested that a moderately intensive exercise intervention (four sessions per week) had a significant effect on quality of life. A review by Dibble, Addison and Papa (2009) suggested that exercise had a moderately positive effect on both balance and postural instability in those with PD. This review however, found that there was no substantial evidence to suggest that exercise has an impact in quality of life. Improvements in balance following exercise were also suggested by Allen, Sherrington, Paul and Canning (2011) who conducted a meta-analysis on the previous data for exercise interventions on balance. This meta-analysis concluded that moderate exercise in those with PD had a positive effect on balance outcome measures.

Baatile et al. (2008) investigated pole striding as a form of exercise for those with PD. Participants completed the exercise three times a week for eight weeks. Participants completed the UPDRS and PDQ-39 as outcome measures. Participants significantly improved in both the UPDRS and PDQ-39. For the dimensions of the quality of life scale, participants significantly improved in mobility and activities of daily living. This study showed preliminary findings that exercise may be beneficial for quality of life, however a low sample size of six male participants give this study low statistical power. This finding is contradicted by Cruise, Bucks Loftus, Newton, Pegoraro, and Thomas (2011) who investigated cognition, mood and quality of life following an exercise intervention. In this study, 15 participants completed an exercise intervention that focused on both aerobic and anaerobic exercises over 12 weeks.

Participants showed a significant improvement in executive function in cognition. No changes were observed in mood or quality of life following the intervention. These findings suggest that exercise may have some benefits for cognition but changes in mood and quality of life may not be seen following exercise.

2.3 Sensorimotor Synchronisation (SMS) and Rhythm

Sensorimotor Synchronisation is the innate human ability (Honing, 2012) to coordinate motor movement to an external rhythmic source (Repp, 2013). This is the capability of being able to move your body in time with a rhythmic beat. This can be a musician playing in time to the rest of the orchestra (Repp, 2005) or dancing along to a piece of music. The majority of previous research has measured this in simple terms of tapping along to a strong beat such as a metronome (McAuley, Jones, Holub, Johnston and Miller, 2006: Thaut, McIntosh, Rice, Miller, Rathbun & Brault, 1996).

McAuley, et al. (2006) conducted research into SMS differences across a wide range of ages. The researchers investigated children from as young as four years old and compared them to age groups up to an age of 95. It was found that SMS was fairly consistent across the life span after the age of around seven years old, such that SMS ability did not significantly differ between children, adults and older adults. Elderly participants did not show a significant decline in synchronisation abilities. Although healthy elderly adults maintained SMS capacity, children with motor disorders (such as developmental co-ordination disorder) had a deficit in this area (Repp & Su, 2013).

Movement to a strong beat has been investigated in those with PD and stroke as a form of rehabilitation (Thaut et al., 1999; Thaut, et al., 1996; McIntosh, Brown, Rice & Thaut, 1997). Hausdorff (2009) suggested that those with PD have higher variability in gait and stride than controls, which was improved when RAS was used to pace walking movements. McIntosh et al. (1997) suggested that those with PD were able to modify their stride length and pattern, to match a beat. This was observed when participants were both 'On' medication, but also when

they were taken off. Improved gait, stride length and cadence were also seen after three weeks Rhythmic Auditory Stilulation (RAS) home based training. This involved walking to rhythmically accentuated instrumental music with increasing tempo over the three weeks.   This suggests that auditory cues from RAS can improve walking in those with PD. Nieuwboer, Feys, De Weerdt, and Dom (1997) suggested that due to the disruption of the basal ganglia, people with PD are more heavily reliant on external cues. The researchers hypothesized that visual and auditory cues could bypass the degenerated areas of the brain affected in PD and influence the primary motor cortex without passing through the basal ganglia and supplementary motor area. This may suggest that those with PD can use different cortical routes in order to process motor movement.

This research suggests that those with PD can benefit from cueing using a strong beat. So far the research has focused on gait and walking, it is unknown whether using a beat would help other motor symptoms of PD.

There have been a number of fMRI studies that have investigated the effect of rhythm on different areas of the brain. Notably, Bengtsson et al. (2009) found that participants listening to rhythmic beats compared to random sequences showed activation in the motor and premotor cortices and cerebellum. This suggests that the areas of the brain that are involved in preparing our bodies for movement are activated when listening to a rhythmic beat. Grahn (2009) proposed that as humans, when music is played we are likely to move along to that beat, that motor networks may be implicated in the processing of rhythm and beat.

Grahn and Brett (2009) conducted research into beat perception in those with PD compared with healthy controls. Participants had to discriminate whether the rhythms of two sequences differed in either a beat based condition or non beat based condition. Participants were required to listen to a rhythm twice and then indicate whether a third rhythm followed the same beat structure or differed. The rhythmic and non rhythmic beats differed for participants such

that the rhythmic beat followed a predictable sequence and the non rhythmic beat did not. An example of this is seen in Figure 2.4.

Rhythmic

X				**X**				**X**			
1	2	3	4	1	2	3	4	1	2	3	4

Non Rhythmic

X		**X**			**X**			**X**	**X**		
1	2	3	4	1	2	3	4	1	2	3	4

Figure 2.4 Differences between a rhythmic and non rhythmic beat

During half the trials, the third rhythm was different from the previous presentations. It was found that those with PD were significantly worse at discriminating between different sequences in the beat based condition. There were no significant differences between PD and controls in the non beat based condition. Grahn and Brett (2009) suggest that this means that those with PD are either unable to interpret the beat structure when listening to the sequence or cannot recall it to discriminate other beats against. These findings together suggest that in healthy individuals the basal ganglia have a role in discriminating beat, whereas those with PD have a deficit in the basal ganglia and are significantly worse at completing this task than healthy controls. Although this research shows a deficit in beat processing ability in those with PD, participants were not completely unable to discriminate the beat structures suggesting there is some function still remaining. These results are in line with fMRI data that suggest the basal ganglia is involved in the ability to process the beat (Grahn, 2009).

Research has also suggested that the cerebellum and basal ganglia may be involved in the reproduction of rhythmic beat. Penhune, Zatorre and Evans (1998) suggested that both the cerebellum and basal ganglia are both involved in motor timing. The researchers used PET scans to investigate the role of the

cerebellum, basal ganglia and sensory activation areas.   Participants were required to copy rhythms of differing complexity by tapping the beat on a keyboard. Results suggested that the cerebellum was involved in producing timed motor movements. The basal ganglia were also activated, although the researchers qualify that this may be more to do with executing the motor movement than timing. Zatorre, Chen and Penhune (2007) discussed the role of the basal ganglia, supplementary motor area (SMA) and cerebellum in their review of the literature, suggesting that the basal ganglia and SMA may be involved in the initial action selection rather than the fine timing.

The above research discusses the role of certain areas of the brain that are involved in rhythm and beat perception as well as rhythm reproduction. The research has suggested that the areas involved in rhythm and timing, such as the basal ganglia, are impaired in those with PD. It would be predicted that rhythmic timing in those with PD would be affected negatively because of this. This infers that those with PD will have a deficit of internal rhythm keeping and ability to reproduce rhythmic beats. Grahn and Brett (2009) suggest that although there is a deficit for those with PD, there is still some function remaining.

One activity that requires movement to a rhythm is dancing. Brain imaging techniques have been conducted while participants have been dancing. Brown, Martinez and Parsons (2006) used PET scans to investigate brain activity in amateur and trained dancers completing tango steps to music. This research demonstrated a number of brain areas showing activation whilst participants moved their feet in tango steps to a predictable beat. Beat information appears to be represented in areas within the cerebellum from the medial geniculate nucleus. The basal ganglia, more specifically the putamen, were found to be involved in selecting movements in particular rhythmic actions. This research suggests that the same areas of the brain are becoming active whilst dancing to music, as finger tapping to music. This suggests that even simple movements to a beat can activate areas of the brain affected by PD. This research has, however has been criticised for its simplistic methodological nature. Even though participants are completing tango steps while music is being played, this may not

be the same as the processes involved when naturally dancing (Karpati, Giacosa, Foster, Penhune and Hyde, 2015), see Figure 2.5.

Figure 2.5. Example of participant dancing (Brown et al. 2008)

The rest of the body of the participant was completely in the PET scanner and participants had a needle in their arm. This is not how someone would naturally dance and therefore results may not give us an accurate picture of what is happening whilst dancing. This study demonstrated the activation of the putamen of amateur dancers while completing tango steps. The putamen is involved in selecting actions, especially those that have been learnt and become habitual. As there was no control group of non dancers, completing other habitual activities, it is difficult to conclude that dancing specifically activates the putamen. It may well be the case that the putamen is activated in this task because the participants were familiar with the movements and not specifically the music and rhythm aspects of the study.

2.4 Dance and PD

It has been noted that dance can have a positive effect on a number of outcome measures for general health in the elderly population (Hui, Chui, & Woo, 2009). Research has investigated whether benefits for general health can be found in participants with movement disorders, namely PD (Hackney, Kantrovich &

Earhart, 2007). This research suggests that dance can have a significant positive effect on mobility and balance, as well as improved quality of life (Hackney, Kantrovich & Earhart, 2007a; Hackney & Earhart, 2009a, 2010b; Westheimer, 2008).

There is a limited pool of published research investigating the effect of dance on physical outcomes in PD. A number of key questions are explored in this early stage research. This previous research will be discussed up to the point of starting this PhD (09/2011).

2.4.1 Dance vs. exercise

Hackney, Kantrovic, Levin and Earhart (2007) and Hackney, Kantrovic and Earhart (2007) conducted the first research into the effects of dance classes in comparison to exercise in participants with and without PD. Two groups, Argentine tango and exercise were examined, with participants completing two, one hour classes per week of both interventions. This is one research study, published in two papers, Hackney et al., (2007a, 2007b). Assessments were completed a week before the intervention and in the week subsequent to the last session. Participants were assessed on a number of measures, including depression, balance and gait. Outcome measures included the Berg Balance Scale (Berg, Wood-Dauphinee & Williams, 1995), Unified Parkinson's Disease Rating Scale (Fahn & Elton, 1987), Freezing of Gait questionnaire (Giladia, Shabtaia, Simona, Biranb, Talc, & Korczyn) Timed up and Go (Posadilo & Richardson, 1991). Participants also completed the Philidelphia Geriatric Centre Morale Scale (Lawton,1975), walking velocity (measured by the use of motion capture equipment), functional reach (Duncan, Weiner, Chandler & Studenski, 1990), one leg stance (Vellas, Wayne, Romero, Baumgartner, Rubenstein & Garry ,1997), Activities Balance Confidence Scale (Powell & Myers, 1995) and Falls Efficacy Scale (Hill, Schwarz, Kalogeropoulos & Gibson, 1996). When analysing the tango group for participants with and without PD, the paper states that only those with PD completing tango showed a benefit on all measures. Whereas, the control tango group only showed improvement in one leg stance but no other measures. However, improvements in the PD group appear to be a trend rather than

statistically significant with a number of the *p* values not being reported the majority of p values are not reported even though Hackney et al. (2007a) claim there is an improvement. As there is no data reported for these measures, we cannot be sure whether there were improvements, whether there is a trend or results are statistically significant. The ABC and FES are discussed as outcome measures within this study, although means and p values have been omitted from the results. All p values in the table are reported within groups. Between groups comparisons were conducted for Hackney et al. (2007b) for the BBs, UPDRS III, FOG and TUG. No main effect of group or interaction between the groups were observed for these outcome measures.

These two papers suggest that both exercise and dance can produce some improvements in outcome measures. Balance was improved in the tango condition and not in the exercise condition, however this was not shown when groups were directly compared. This would suggest that there were no significant differences between exercise and tango groups on any of the outcome measures.

There were differences in the format of these two interventions. Within the description of these classes, the author's explain that participants of the tango group completed an hour's class, in which both warm up and main activities were completed whilst standing. The main activity was completed with younger volunteers in a partnered stance. This differs from the exercise group that were seated for the first 40 minutes of the hour-long class, for both the warm up and then seated exercise. The class then went on to standing exercises for 10 minutes and the final 10 minutes of stretching on the floor. Although these activities do involve dance and exercise, they appear to require differing levels of intensity.

This research gives a good starting point to examine the role of dance compared with exercise but by no means does it give us a definitive answer as to which is most beneficial for those with PD. These studies investigated only balance and mobility measures, and not the non motor symptoms of PD.

Levels of Metabolic Equivalent (METS) have been explored previously in Jette, Sidney and Blümchen (1990) in which a list of number of METS expended during a variety of exercises was produced. These METS suggested that different dance and exercise classes vary for energy expenditure. Additional forms of dance have been updated since this paper, to include different forms of dance. A list of dance forms and their associated METS can be seen in table 2.1.

Table 2.1 METS table for dance

METS	Type of dance
5	Ballet, Modern and Jazz class
6.8	Ballet, Modern and Jazz class (vigorous)
4.8	Tap
7.3	Aerobic
3	Ballroom slow (Waltz, Foxtrot, Tango, Samba, Mambo, cha cha)
5.5	Ballroom fast
7.8	Disco, Folk, Irish dancing, Polka, Country
3.5	Caribbean dance

These METS show the differences in levels of expenditure for a variety of dance forms and give an estimation as to the levels of intensity that different activities provide. The dance for PD research has tended to explore ballroom dancing such as tango and waltz/foxtrot which appear to have the same MET levels.

2.4.2 Tango and other dance styles

The publications by Hackney & Earhart (2009a) and Hackney & Earhart (2009c) are again from the same research project but are published separately within two journal articles. The Hackney & Earhart papers published post 2007 appear to be more statistically reliable than those presented previously, with statistical data and p values being reported. Hackney & Earhart (2009a) omits the tai-chi group and focuses on balance, mobility and gait outcome measures to examine changes from pre to post assessments. This study investigated the physical

symptoms of PD including balance and mobility. Again this paper used the UPDRS III, Berg Balance Scale, BBS (Berg et al. 1995), TUG and Freezing of Gait Questionnaire (FOG). In addition, the 6 minute walk test, 6MWT (Bultand, Pang, Gross, Woodcock & Geddes, 1982) which measures how many metres a participant can walk over 6 minutes was included. Gait measures assessed by GAITrite walkway (CIR systems, Inc) were also investigated. Significant benefits from the tango and waltz/foxtrot interventions were seen on the BBS Balance Scale, 6 minute Walk Test and backward stride length when compared to controls. No significant improvements were found for the UPDRS III for both dance interventions, however, there was a trend towards improvement for the waltz/foxtrot group.

Both the waltz/foxtrot and tango interventions showed a significant improvement in the BBS as well as the 6MWT. This suggests that both interventions had a similar effect on balance and mobility measures. For the gait measures, waltz/ foxtrot and tango also had similar outcomes, with only backward stride length significantly improving from pre to post assessment. However, there was a borderline significant improvement in backward single support time for the tango group that was not observed in the waltz/foxtrot group. These results show that both forms of dance can show improvements in balance, mobility and gait measures. This study has shown significant improvements in balance and walking for both types of dance over that of the no intervention group.

The research presented up until now has focused on the functional improvements that have been observed in those with PD. Hackney & Earhart (2009c) concentrated specifically on the effect of dance on quality of life. This study compared the Argentine tango, waltz/foxtrot (30mins of each during each session), tai chi and no intervention. Sessions were twice weekly for 10 weeks and lasted for one hour. Participants completed the PDQ-39 (Peto, Jenkinson, Fitzpatrick & Greenhall, 1995) to assess quality of life, one week before the intervention and in the week after the 20th session. A significant main effect of time was found for Activities of Daily Living (ADL) and Stigma portions of the

questionnaire. The only group to have significant improvements in Mobility, Social Support and PDQ-39 SI was the tango group. No other group showed significant changes between pre and post assessment. These findings suggest that tango dancing can have an effect on the way PD impacts an individual. This study investigates the improvements that can be made to participants' quality of life.

A number of the Hackney & Earhart papers have suggested that tango is the most beneficial form of dance for those with PD (Hackney & Earhart, 2009a, 2009c). Changes in outcome measures have actually been shown to follow a similar pattern of results following different forms of dance.

Table.2.2. Means table for balance and mobility measures

	UPDRS III		BBS		TUG		FOG		6MWT	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Waltz/ Foxtrot	26.9 (2.5)	24.3 (3.4)	48.1 (1.2)	52.1 (1.2)*	10.9 (7.6)	10.8 (1.2)	7.7 (1.2)	7.6 (1.2)	358.1 (21.7)	407.2 (8.7)
Tango	27.6 (2)	26 (2.5)	48.1 (1.4)	52 (.8)*	12.1 (1.5)	10 (.8)	8.4 (1.4)	7.5 (1.3)	364.2 (25.3)	423.6 (9.6)
Control	27.4 (2.4)	32.4 (2.6)*	48.2 (1.9)	47 (2.5)	12.4 (1.3)	14.4 (2.6)	4.7 (1.4)	5.9 (1.3)	368.4 (27.5)	360.9 (33.3)

Values are means (SE for pre and post values).* = significant difference between pre and post within group, $p < 0.05$

Interestingly, even though there are very similar effects for both the waltz/foxtrot, the researchers suggest that tango dancing may still be more beneficial than other forms of dance. '...*Tango may be preferable for those with Parkinson's disease, as it equaled Waltz/Foxtrot on many measures and had larger effects than Waltz/Foxtrot for TUG as well as forward and backward measures*' Hackney & Earhart (2009a, p.480). As these measures do not show a significant change, this statement seems unwarranted. The data suggests that both waltz/foxtrot and tango dancing both show benefits on the same outcome

measures and therefore both appear to be a viable intervention to improve balance.

Marchant, Sylvester & Earhart (2010) conducted an investigation on the effects of contact improvisation as a form of dance on balance and mobility measures. Contact improvisation can be described as improvised movements that involve lifting, balancing and supporting the weight of another person. This was an intensive study in which 11 participants with PD completed an hour and a half session per day for two weeks. The assessments took place the week before and week after the intervention. Contact improvisation is dissimilar to tango in the way the movements are improvised whereas tango is a much more structured dance. Participants were assessed on the BBS, UPDRS III , FOG, TUG, PDQ-39, functional reach (Duncan et al.,1990) sit to stand (repeated five times), Activities Balance Confidence Scale (Powell & Myers, 1995) the 6 MWT and GAITrite equipment. It was found that there was a significant improvement in UPDRS III and the BBS indicating an improvement in balance and significant improvement on Gait.

The effects of contact improvisation were similar to the benefits reported for tango dancing in previous papers (Hackney & Earhart, 2009a;2009b;2009c;2009d). In fact, this paper goes as far as statistically comparing results with Hackney & Earhart (2009b) that conducted a similar format of dance, with both studies completing intensive dance sessions. In Hackney and Earhart (2009b) the participants again completed two weeks of intensive tango classes and found a significant improvement on the UPDRS III and the BBS. There were no significant differences found between pre and post testing in gait as there were in Marchant et al. (2010). These improvements were found to be significant on both papers, however, Marchant et al. (2010) showed a borderline significant improvement (p=.05) in the TUG that was not observed in the studies exploring tango and ballroom. The improvements were not as great as those completing 10 weeks of tango sessions. Overall, this paper indicates that contact improvisation is as effective, if not more so, than Argentine tango as a short duration intervention for participants with PD. With that said,

these comparisons were made post hoc and not directly compared within the same study.

Batson (2010) explored the feasibility of a modern dance class for participants with PD. Modern dance can be described as a free flowing form of dance in which emotions are portrayed through movement. In this study, 11 participants completed nine modern dance classes over three weeks. Balance measures as well as levels of risk, adherence and cost were primary outcome measures. The class included both learning dance moves from the teacher as well as group improvisation. Participants were early to mid stage people with PD and completed the TUG and the Fullerton Advanced Balance Scale (FAB scale). The FAB scale is a measure of balance, in which participants complete a number of balance tasks (such as standing with feet together with their eyes closed for 30 seconds). Assessments took place three days before the first dance class and in the week after the last dance session. Batson (2010) found that participants significantly improved on the FAB but not the TUG. As well as this, it was found that the classes were cost effective, showed increased overall satisfaction of participants, had a low level of risk, high adherence rate and had social benefits for participants.   The effectiveness of modern dance as an intervention for participants with PD is still relatively unclear as this study uses only two measures to distinguish whether there is a positive effect for participants completing modern dance. A more thorough investigation, using further outcome measures would be needed to determine whether there is a more general benefit of modern dance for those with PD.

Up until this point, the research has followed a similar methodology, with a battery of tests before and after a dance intervention. Heiberger, Maurer, Amtage, Mendez-Balbuena, Schulte-Monting, Hepp-Reymond & Kristeva (2011) used a different format and conducted an investigation into the short term effects of modern dance developed by the Mark Morris Dance company. This study aimed to investigate whether effects could be observed in a number of outcome measures before and after one dance session. This form of dance was used in order to investigate the immediate effects of dance on gait, mobility and

quality of life, as discussed previously. This dance style uses a number of different dances within it that are specifically selected to target issues that participants with PD face (such as jazz steps to improve participants walking, rhythm and coordination). This form of dance has been investigated less substantially than tango, this makes it difficult to ascertain whether this form of dance is beneficial in the same way as the previous research. Eleven participants completed 8 months of 75 minute weekly dance classes. The participants in this study were more severe than in previous research (Hackney & Earhart (2009a, 2009b, 2009c, 2010), as five out of the 11 participants had a Hoehn and Yahr score of IV. Each participant was assessed before and after one dance class, eight months in to the programme. These included the UPDRS III, TUG and Semitandem test (SeTa). The SeTa measures balance by the participant standing in tandem with feet touching for 15 seconds. Participants were also given the PDQ-39 in order to assess quality of life. The only measure that showed a significant improvement was the UPDRS III. These were seen specifically in rigidity, hand movements, finger taps and facial expressions. No changes were seen in TUG, SeTa or quality of life. This finding is important as it shows that there can be an immediate effect on motor skills for those with PD immediately after dancing. This can have functional implications for participants, to improve motor ability immediately after dancing may benefit activities of daily living. This study did not however, investigate the length of time these effects lasted and therefore it is difficult to understand how beneficial this type of intervention is for day to day activities. Do the effects last for minutes or hours?

2.4.3 Partnered vs. non-partnered tango
Hackney & Earhart (2009d) also explored whether there were any significant differences between partnered and non partnered tango on a number of balance, mobility and gait measures. Up until this point, all the tango interventions had been partnered dances. All participants in this study had mild to moderate PD (indicated by a Hoehn & Yahr stage of I-III). One participant with a Hoehn & Yahr score or IV was excluded from the current study and a case study was published on the changes a more severe individual participant could achieve (Hackney & Earhart, 2010c). Twelve participants made up the partnered tango

group, in which both males and females took turns in leading the dance. Within the non partnered group, 15 participants completed the same movements without a partner. Both groups completed identical warm ups and danced to the same music over the 20 sessions. Participants were assessed on a number of balance and mobility measures the week before and after the intervention and at a four week follow up after the post intervention. It was found that both the interventions showed a significant improvement in balance and a number of gait assessments.

Interestingly, it was found that all improvements made at post-testing were seen at the four-week follow up. The 6MWT even improved between post testing and follow up. If participants were not completing any other dance classes post the intervention, this would indicate that the effects of dance classes may last even further than four weeks. Assessment testing a number or weeks or even months after an intervention would be useful to determine how long these effects can be observed. The results of this study show that both partnered and non-partnered tango are showing almost identical gains for those with PD.

2.4.4 Do the effects of dance differ for those more severely affected by PD?
The majority of research that has been conducted in this area has included participants with mild to moderate PD (Hackney & Earhart, 2007a., Hackney & Earhart 2009b; Marchant, Sylvester & Earhart, 2010). As discussed, balance and mobility have improved when participants have this level of severity. Hackney & Earhart (2010c) followed a case study of a more severe participant through the above tango intervention. The participant (KV) completed the same methodology as that of Hackney & Earhart (2009d) and was within the Partnered tango condition. The authors have noted that KV had a much larger benefit from the tango classes than participants with mild to moderate PD. This included a 131% improvement on the Berg Balance test, a 59% improvement on the 6 minute walk test compared to an average of 16% of participants with mild to moderate PD, and a 14% improvement of quality of life (assessed by the PDQ-39, Peto, et al. 1995). When considering the raw scores, the difference in the BBS

equates to mild to moderate participants improving by around 5 points and the severe patient improving by 10 points on the scale. However, the BBS is known to have ceiling effects which may be a reason for why the severe participant (with a much lower pretesting raw score than mild to moderate participants) improved more than those with mild to moderate PD. In terms of the 6MWT participants with mild to moderate PD are walking on average 350 metres at pretesting and then improving to around 400-420metres by post testing. When compared to the severe patient case study, Hackney & Earhart state a 59% improvement, which is higher than the mild to moderate patients, however at pretesting the severe patient could only walk 13 metres showed an improvement to 21 metres. Although there is a significant improvement for the severe patient, in reality the comparison between participants is not really justified as the severe participants score improved by six metres, whereas the mild to moderate participants improved by approximately 50-70 metres. This demonstrates a benefit can be had for participants with severe PD as well as those with mild to moderate stages of the disease. Obviously these findings are from one case study, following a single participant through intervention and assessments and results can not be generalised to the wider population. The same effect may not be observed with other severe PD participants. The severity of KV is also unclear as there is ambiguity regarding the Hoehn and Yahr staging of the participant in the text, with the participant being referred to as both IV and V. It would be assumed that KV was at stage IV due to the mobility the participant is described as having within the paper.

2.4.5 Duration of intervention and time of assessment
Each of the studies outlined previously have had different durations of intervention. The shortest intervention was used by Hackney & Earhart (2009a) and Marchant et al. (2010). In these studies participants engaged in two weeks of intensive dancing, one and a half hours per day for 10 sessions. This was found to have significant beneficial effects on balance measures.

Batson et al. (2010) used a three week intervention to assess the feasibility of a modern dance class for those with PD. Within this study there were three dance

sessions per week. This may be more appropriate for those with PD as even though it is fairly intensive, there will be rest days to recover from the exercise. However, as this was a preliminary study to assess the practicality of the format, it is unclear the effect this would have on balance and mobility measures as seen in Hackney & Earhart (2009a) and Marchant et al. (2010).

A number of the studies discussed in this review have used interventions of 20 sessions over approximately 10 weeks (Hackney & Earhart, 2009c, 2009d). This duration of intervention has shown a number of times that significant improvements can be seen on balance and mobility measures. Assessments of participants, throughout the research have been relatively standardised at one week before the intervention begins and one week after the last session (Hackney & Earhart, 2007, 2009). This approach has found a number of balance and mobility measures have improved when compared with the assessments before the intervention. However, this has not been the case in every study. Hackney & Earhart (2010d) conducted pre and post testing and then follow up testing 4 weeks later. As it was found that participants improvements held steady after 4 weeks and even improved on a few, follow up testing appears essential to discover how long the effects from dance classes can last.

Heiberger et al. (2011) completed assessments before and after each dance session. These showed few improvements on the outcome measures, indicating that this may not be the most effective way to measure motor skills. However, this technique may be useful as part of a study that also uses pre and post testing as an additional measure for questionnaires for example. Heiberger et al.(2011) completed approximately 20 minutes assessment before and after the dance class. The problem with using these measures before and after a session is that participants' assessment times after dance will vary substantially. This disparity would not give a clear picture of the changes following an intervention of this type. There may also be fatigue issues with participants completing 20 minutes of assessments before and after a dance session.

There has also been limited research into the long term effects of dance on the symptoms of PD. Duncan & Earhart (2011) were the first to measure changes in outcome measures at a number of time points, namely 3, 6, and 12 months after pre assessment. Over time a number of measures showed an improvement and then plateaued, indicating that a potential ceiling effect in which participants no longer improve. This could indicate the benefits of dance can only offer so much improvement within this disease. When investigating the UPDRS III, there was a 12 point drop in the mean scores of the tango group. This shows a large effect. In comparison to other studies using the UPDRS III (Hackney & Earhart, 2009c) participants were more severe and therefore had higher UPDRS III scores at baseline. These scores decreased to similar scores seen at pre-testing of mild to moderate patients. Further research would need to be conducted to see whether such a large drop would be held up in mild to moderate participants over a one year intervention. This study in comparison to controls shows that in a one year period, those in the dance group did not show the same decline as controls. Further research into the neuroprotective effects of dance would be beneficial in order to investigate whether these interventions could in fact slow disease progression. This study shows an improvement in quality from the previous research as it uses a number of measures over different time points in order to track progression. Questions still remain unanswered however.

2.4.6 Participants

There were some participant drop outs in the previous research but overall adherence rates were promisingly high compared with exercise programmes (Hackney & Earhart, 2009ab). There could be a number of reasons for why there was high adherence rate between the studies such as the sociability and group atmosphere for example. This is unknown as exit questionnaires were not implemented.

2.4.7 Literature

For Marchant et al. (2010), six of the 11 participants had already completed PD and tango interventions, over a year previously. It is unclear whether these participants had taken up dance activities relating to this previous research.

This may have had an effect on the results of this study as participants may have practice effects from completing these tests prior to the study. The paper revealed no significant differences in the 6MWT before and after the study. When comparing the mean data for this, it became clear that participants were already walking a considerable distance in six minutes, almost 100 metres more than in any other baseline measurement from previous research (Hackney & Earhart, 2009a, 2009b). Participants then only improved a very small amount at the post testing assessments. This is potentially due to the participants being at the ceiling of how far it is possible to walk in six minutes already. This study highlights the issues that can arise from using the same participants in a number of similar studies. Even though the authors argue there to be no effect still present, there may well be which would interfere with the data. As there are no studies investigating exactly how long the benefits of a three month intervention would last, it is impossible to know whether an intervention a participant completed a year ago would affect certain outcome measures in the present.

The previous research has given an insight into the role of dance on the symptoms of PD. There have been suggestions that dance is more beneficial than exercise. However, there are a number of issues with almost all the research that has come so far, whether it be methodological issues or statistical problems. There are some key points that need addressing to make this research more rigorous and help us to answer the question of whether dance does in fact improve the symptoms of PD.

The previous literature published before the beginning of the PhD has predominantly focused on tango and its effect on PD. This research was mostly been conducted by one group of researchers (supervised by Gammon Earhart at Washington University). Since these initial papers there have been research studies investigating a range of other forms of dance (Irish Jig, modern dance, improvised dance, ballet and a combination). There have been relatively few other groups that have investigated the role of tango on PD; Blandy, Morris and Beevers (2015), and Romenets, Anang, Fereshtehnejad, Pelletier and Posthuma

(2015). This section will investigate all the literature into the effects of dance published during the PhD.

Blandy et al. (2015) completed a small feasibility study on six participants with PD. Participants completed twice weekly tango classes of one hour for four weeks. Again pre and post assessments were completed before the fist session and on conclusion of the last tango session. The main focus of this research was to assess feasibility, although the researchers did include some outcome measures to assess change in selected outcome measures after the dance sessions. This study focused on changes in depression and quality of life and did not investigate motor changes. Tango sessions appeared to show significant improvements in feelings of depression (as measured by the Beck Depression Inventory; Beck, Ward, Mendelson, Mock and Erbaugh, 1961) but no changes in quality of life were observed. Overall the findings were focused on showing that this type of research is feasible and can be enjoyable for participants. It also showed that depression can be significantly improved following tango sessions, however this study did not find any change in participants quality of life.

Another study investigating the effect of tango was conducted by Romenets et al. (2015) this study investigated the effect of tango whilst comparing participants with a control group. Participants in the tango group completed twice weekly sessions for 12 weeks, those in the control group were given information regarding exercises that they should complete at home. Participants were given a battery of assessments at baseline and after the intervention including the mini BESTest. The mini BESTest is a measure of balance that integrates portions of the BBS and the TUG. The study found significant improvements for TUG and dual TUG for the tango group that was not observed in the control group. There was a significant interaction for balance, as measured by the Mini-BESTest, although follow up univariate ANOVAs showed no change for either group. There were no significant changes in MDS-UPDRS dimensions, quality of life, depression, cognitive tests or feelings of apathy and fatigue. This study did find significant improvements in TUG and a suggestion of improvements in the MiniBESTest, which does tie in with the previous tango and PD literature

published by Hackney & Earhart (2009abd). There are some differences, however, with no changes in symptoms of PD, as measured by the MDS-UPDRS. This study also found no changes in depression, which differs from Blandy et al. (2015). Reasons for this could be due to the intensive nature of the dance classes, compared to the longer duration study by Romenets et al (2015).

These two studies investigated the effect of tango, other studies have also looked at other forms of dance and their effect. Up until this point, the only other study to investigate contact improvisation on the symptoms of PD was Marchant et al. (2010). Batson, Migliarese, Soriano, Burdette and Laurenti (2014) also conducted research into the effect of improvised dance for those with PD, but in a less intensive format. This study included only seven participants completing improvised dance classes, three times weekly for seven weeks. This study was split into two phases. The first phase was the improvised dance with pre and post assessment sessions before and after the seven week block of dance. Participants were measured again for changes in TUG and dual TUG (completing the TUG test whilst engaging in a cognitive task) as well as balance. Balance was assessed using the Fullerton Advanced Balance Scale (FAB) rather than the BBS that have more commonly been used in the literature. This study found improvements in balance (p=.017) although no changes were observed in the TUG or Dual TUG. The literature discusses a trend for improvement in these measures but statistical analysis was not provided to support this statement. The second phase of this study included a one participant case study using fMRI. Three months after participants completed phase one, the participant with largest improvements from the sessions was given an fMRI scan. The participant received the scan pre and post five days of intensive improvised dance sessions (1hour per day for five days). The fMRI showed some neuroplastic changes in brain maps following the dance sessions. The authors suggest changes in the connections between basal ganglia and premotor regions were increased, which may lead to improvements in balance and motor control. This links with mechanistic explanations of Earhart (2010) that suggested that dance may activate basal ganglia in those with PD.

The Irish jig has also been examined for those with PD (Volpe, Signiorini, Marchetto, Lynch & Morris, 2013). Participants completed either physiotherapy exercises or Irish jig dance sessions once weekly for 6 months. Participants were also required to complete a home programme of their group for at least one hour per week. Twelve participants in each group completed assessments of the UPDRS III, TUG, BBS, FOG questionnaire and PDQ-39, before and after the intervention. Both Physiotherapy and Irish dancing groups showed improvements over time for UPDRS III and TUG, these were significantly greater for the Irish jig group than the Physiotherapy group. The BBS showed a borderline significant improvement for both groups (*p*=.05). The FOG was significantly improved in the Irish dancing group and not the Physiotherapy group. It is unclear whether any changes were observed in the PDQ-39 as data were not reported.

Shanahan, Morris, Bhriain, Volpe, Richardson and Clifford (2015) also investigated the effect of Irish jig on PD. Ten participants with PD completed eight weeks of dance, on a once weekly basis. Participants also completed a home-based programme, similarly to Volpe et al. (2015). Pre and post assessments were taken before and after the intervention. This study was predominantly run to assess feasibility, although a number of outcome measures were tested pre and post. Findings suggest significant improvements in UPDRS III and PDQ-39 but no change in BBS or the 6MWT. Interestingly, this is one of the only papers to show no change in the BBS. This contradicts the previous research that has consistently shown improvements in balance.

These studies showed alternative forms of dance that can be beneficial for those with PD (Irish jig and improvised dance). More interestingly, the pattern of results differs for this study to previous Hackney & Earhart findings of improved balance for those completing dance sessions and is similar to Romenets et al. (2015) that found limited changes in balance. This study also showed a significantly improvement in TUG which was only seen as a trend in Marchant et al. (2010) who explored the effect of improvised dance and significant improvements in Batson et al. (2014) who investigated the effect of modern

dance on those with PD.   Results from the PDQ-39 were unclear in the text for Volpe et al. (2013) both groups showed 'similar outcomes' however it is not described whether they both improved significantly or not. Details not discussed in the text would suggest no improvements were observed. Shanahan et al. (2014) did show improvements in PDQ-39, this adds to the literature that is unclear whether dance shows changes in quality of life.

In comparison to previous research, Hashimoto, Takabatake, Miyaguchi, Nakanishi and Naitou (2015) investigated a mix of dance styles on its effect on PD. During this study, three groups were compared, dance, exercise and control. The dance group completed dance sessions which included jazz, modern, tango, ballet, pantomime and improvised dance styles. Those completing exercise were given physiotherapy exercises presented by video or book. The third group, a control group of those with PD that did not make any changes to their everyday routines. Participants completed 12 weeks of intervention, once weekly with assessments pre and post intervention. Similarly to previous research, the authors investigated the role of balance (through BBS), gait (TUG) and disease severity (UPDRS). Additionally, convergent thinking was assessed using the Mental rotations task (MRT) to assess motor planning ability and cognitive function by the Frontal assessment battery (FAB) to assess six different areas of cognition: conceptualization, mental flexibility, motor programming, interference, inhibitory control, and environmental autonomy (Dubois, Slachevsky, Litvan & Pillon, 2000).   Results showed significant improvements for BBS for the dance group, neither of the other groups showed change in time from pre to post assessments. Univariate ANOVA's for the TUG showed significant improvements in both the dance and exercise groups and no change in the control group. There was a significant improvement on total UPDRS scores from 42.7 to 23.1 for the dance group and no change for either of the other two groups. Significant improvements were seen in both FAB and MRT at post compared to pre assessment. With both dance and exercise groups showing significant improvement in FAB following the intervention and again both exercise and dance groups having an improvement in speed of response times in MRT, with no change on total correct responses.

These findings suggest that both dance and exercise can show some positive change in cognition following dance. This research by Hashimoto et al. (2015) has shown a link between dance for PD and cognition. This requires further exploration to see whether dance can improve cognitive in those with PD.

Overall, the results of this study are in line with previous research that has found improvements in BBS and some research suggesting change in TUG. There was a large mean change in UPDRS scores for the dance group, with no changes in both the exercise or control groups. This significant improvement does fit with previous research, although the mean change is larger than would be expected given previous literature. This was also the first study to investigate cognitive tasks, and found significant improvements in the response time for both the dance and exercise groups, with no effect on number of correct responses.

Research has also investigated the effect of a dance computer game on the symptoms of PD, Lee, Lee and Song (2015). This study had participants complete a virtual reality dance game on the Nintendo Wii five times a week for 30minutes. The intervention lasted for six weeks. This experimental group was compared to a control group. Both groups were receiving physiotherapy five time per week, but the experimental group received the virtual reality game additionally. After the intervention, BBS was significantly improved in the dance group, as were levels of depression and perceived ease of activities of daily living. There were no changes observed in the control group.

This study suggests that people with PD may be able to improve balance, depression and activities of daily living by using an interactive device. This could potentially be used by participants in their own home and could be useful for those unable to get to dance groups. This study, however, was conducted with a relatively small sample size (10 participants in each group) and therefore further research into this form of dance is required. An interactive dance resource requires more research in order to investigate different forms of dance, intensities etc that would be beneficial for participants.

Longer term effects of dance on PD were investigated by Duncan & Earhart (2012). Twenty six participants completed 12 months of tango dancing and 26 were in the control group. Both groups were assessed before the intervention began, then again at 3 and 6 months into the study, and again at 12 months, once the study was completed. Interestingly, this is the first study to assess participants 'OFF' medication. The rationale for this is that participants will show a more reliable assessment without anti-PD medication interfering. Participants ranged from I – IV on the Hoehn & Yahr scale (Hoehn & Yahr, 1967) indicating participants ranged from mild to severe PD, this differs from previous research that has predominantly used mild to moderate participants. Participants completed a number of outcome measures at each assessment, these included the UPDRS I- III, 6 MWT, Freezing of Gait Questionnaire, 9 hole peg test (measures upper extremity function), Mini BESTest and GAITrite technology. It was found that balance improved in the tango group at 3, 6 and 12 months compared with baseline off medication. Indicating that balance did improve from baseline but did not significantly improve between 3, 6 and 12 months. This would suggest that the improvement plateau after the initial improvement. Balance in the control group significantly decreased in control condition over the 12 month period. There were no differences in the freezing of gait between the tango and control groups throughout the 12 months, however, the control group had significantly more freezing at 12months compared with pre-testing. Within the UPDRS III, motor symptoms significantly improved over the 12 months compared with the control group. The tango group improved at 3 months compared to pre-testing, and improved again at 6 months compared to 3 months. There were no improvements from 6 months to 12 month assessments, within the UPDRS III, bradykinesia showed the same trend. This suggests that motor symptoms improve to a point and then tail off after 6 months of tango dancing. Rigidity increased in the control group compared with no change in the tango group. This indicates that tango dancing may slow down the natural progression of some aspects of the disease. The distance covered in the 6 minute walk task decreased in the control group and stayed the same in the tango group. Within the 9 hole peg test, participants in the tango only showed an

improvement at 12 months compared to pre-testing. It would be interesting to discover whether this would improve if the intervention were longer than 12 months. As the improvements were only identified at 12 months, it appears to be the case that more fine movements such as hand movements take longer to show an improvement. Alternatively, the Argentine tango intervention may not have regularly used specific fine hand movements and therefore did not show an improvement until further into the study.

Foster, Golden, Duncan & Earhart (2013) investigated other activities of participants during Duncan & Earhart 's (2012) research study. The researchers explored the number of social activities and hobbies that participants were engaging with during and after the stud. It was found that those completing the tango sessions had higher activity retention of old hobbies and participation in new activities after beginning the research study than those in the control group. This research suggests that completing dance sessions may transfer to other social groups. Those completing the tango condition, increased their level of activity and sought out new activities. This has implications for analysis – is it the dance sessions that are showing improvement over time or the new social activities that are being started off the back of the research project? Obviously it is beneficial for participants to be completing new activities, however if participants sought out additional social activities during the study, this may have had a baring on their 3,6 and 12 month assessments. This may indicate that participants improved mobility may be due to completing a number of activities each week rather than solely the dance intervention.

Duncan & Earhart (2014) also conducted a two year pilot study into the effects of Argentine tango long term. This study had five participants complete argentine tango for two years in comparison with a five person control group. Participants in the experimental group completed a one hour class, twice weekly for two years, with assessments at baseline, 12 and 24 months. Participants were measured on all sections of the MDS-UPDRS (1-4), miniBESTest, forward and backward walking, TUG, dual TUG, 6MWT and FOG questionnaire. At baseline, groups did not significantly differ on any of the outcome measures. For the MDS-

UPDRS III, significant group by time interactions were observed at 12 and 24 months, suggesting that argentine tango can show significant improvements in motor severity after 12 months. Figure 2.6 shows the pattern of results between assessments for MDS-UPDRS III, it is clear to see that after 12 months, improvements plateau, in comparison to the control group in which motor severity gradually gets worse over the two years.
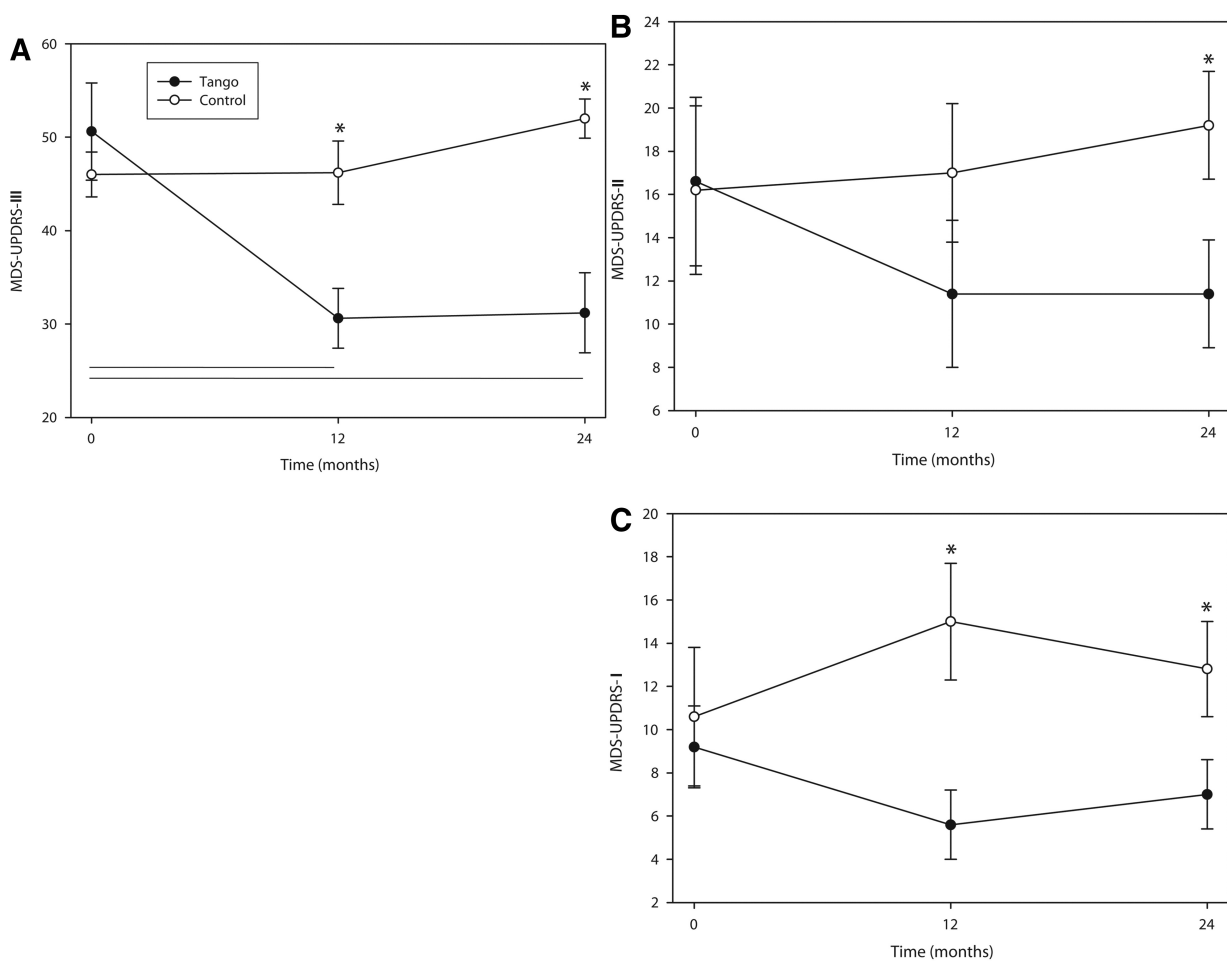
Figure 2.6 MDS-UPDRS I & II & III changes at baseline, 12 and 24 months (Duncan & Earhart, 2014)

These results show that all improvements in motor severity may be observed within the first year of class attendance, after which participant's symptoms

keep steady. This is in comparison to the control group in which symptoms have continued to worsen.

There was also a significantly group by time interaction for the Mini BESTest at 12 and 24 months. There was a significant interaction for Dual TUG, such that the experimental group improved and control group worsened. No main effects or interactions were observed for forward and backward walking, TUG, FOG or 6MWT. These findings suggest that argentine tango sessions are beneficial long term for both motor severity and balance. This study found no change in gait or freezing of gait at any time points. This is the first study to investigate changes after tango classes for longer than one year. Although these results are promising, the groups had a very small sample size, with just five participants in each group and therefore further research needs to be conducted to into the long term benefits of dance on symptoms of PD. This research taken with Duncan and Earhart (2012) suggest that long term attendance at dance classes have a sustained effect on the symptoms of PD.

Research has also explored the comparison between dance and a social groups. McKee & Hackney (2013) compared tango dancing with an education programme for participants with PD on both spatial cognition and motor function. This study aimed to investigate whether those completing a social task with no physical movement would have any effect on outcome measures. Participants completed 90 minutes of weekly sessions for 12 weeks either completing tango classes or a one hour lecture followed by a group discussion on health related topics. There were 23 participants in the tango group and eight in the education group. Participants were measured on UPDRS III, Fullerton Advanced Balance Scale, Freezing of Gait questionnaire, TUG, Dual TUG, PDQ-39 and spatial cognition. Results showed that spatial cognition significantly improved from pre to post assessment for the tango group and not the education group. In terms of disease severity, a significant improvement for the tango group was seem for the UPDRS III, whereas only a trend was observed for the education group. Significant improvements were observed for the FAB scale for the tango group that were not seen in the Education groups. There were no

significant effects for either group for the TUG, Dual TUG, FOG or PDQ-39. These results suggest that balance and disease severity were improved significantly in the tango group compared to the education group.

Using an education group to compare the tango group is a useful way to investigate whether using a social group or group learning would also show the same results as those completing tango. Importantly this group does not complete the exercise component of the dance class. The sessions were 1.5 hours of education, in which one hour was passive learning with only 30 minutes of group activity. These are very different activities, with the tango group completing Partnered and therefore a more social activity than the education group that were attending lectures. There is also quite a disparity in sample sizes in the data, with 8 participants in the education group and 23 in the tango group. The groups were not well matched on key aspects of the task, and different dramatically in group sizes, which limits the statistical power of the research.

The research considered up to this point, has suggested that there may be significant improvements in balance and quality of life following dance sessions. This however, is not conclusive. Romenets et al. (2015) did not find improvements in balance after completing tango sessions, and Volpe et al. (2013) suggested only a trend towards improvement after 10 weeks of Irish jig.

A number of review papers have been published in this emerging area of research. These include reviews of the literature and also recommendations for class implementation (Hackney & Earhart, 2010).

Review papers:
Earhart (2009)
Tomlinson et al. (2013)
Earhart & Falvo (2013)
Hackney & Bennett (2014)
McGill, Houston & Lee (2014)

Mandelbaum (2015)

McNeely, Duncan & Earhart (2015)

Meta-analyses:

DeDreu, Van der Wilk, Kwakkle and Wegen (2012)

Tomlinson et al. (2013)

Sharpe & Hewitt (2014)

Shanahan, Morris, Bhriain, Saunders & Clifford (2015)

Lötzke, Ostermann, & Büssing (2015)

DeDreu et al. (2012) conducted the first meta-analysis including papers investigating the effect of dance on the symptoms of PD. This analysis did not solely focus on dance for PD, but 'Rehabilitation, exercise therapy and music' and included a range of studies, including dance, music therapy and walking with music. This meta-analysis included six studies, three of which investigated dance (Hackney, Levin, Kantrovic and Earhart, 2007; Hackney & Earhart, 2009a; 2009b). For three outcome measures, the BBS (Berg et al. , 1995), the TUG (Mathias et al. , 1986) and the FOG (Gilaldi et al. , 2000) the three dance studies were compared without the other forms of intervention. These findings suggested a significant improvement for both the BBS and TUG in this meta-analysis. There were no significant changes observed for the FOG questionnaire. This gives us reason to believe that there are beneficial effects on these outcome measures, with only three studies included however, it is difficult to make any strong conclusions from this meta-analysis.

Both systematic review and meta-analyses were conducted by Tomlinson et al. (2013). This analysis was focused on a range of physiotherapies as interventions for those with PD. This study investigated whether differing physiotherapies had an effect on gait, balance, disability rating scales and quality of life. Two studies investigating the role of dance on outcome measures were included in the meta-analysis (Duncan & Earhart, 2012;Hackney & Earhart, 2009a). Other interventions included physiotherapy, exercise, treadmill training, cueing and martial arts. Within Gait, speed significantly improved following the

39

physiotherapy interventions, there was a borderline significant improvement for the Six Minute Walk Test and the FOG questionnaire. There were no differences between groups for cadence, stride length and step length. For balance, there was a significant improvement in the TUG, functional reach test and BBS. There were no differences for the Activity specific balance scale. The UPDRS III scale also significantly improved following the physiotherapy interventions. There were no significant changes for the PDQ39, however. The number of falls participants had after the interventions also decreased. Overall, this meta-analysis shows that interventions such as those described above can have a significant beneficial impact on participants. Only two studies investigating dance were included in the analysis, therefore any strong conclusions from this meta-analysis and the role of dance for PD cannot be drawn.

Sharpe and Hewitt (2014) conducted the first meta-analysis to exclusively investigate the role of dance on the symptoms of PD. This study identified seven relevant papers to be included in the analysis (Duncan & Earhart, 2012; Foster, Golden, Duncen & Earhart. 2013;Hackney et al; 2007a, 2007b; Hackney & Earhart, 2009a, 2007c; Volpe et al. , 2013), of which there were five experimental studies. Again this meta-analysis focused on physical measures of PD. For each of the plots, two research studies were included. For the UPDRS III, two meta-analyses were conducted, dance vs. exercise showed no difference between the interventions (p=.21), dance vs. no intervention showed a significant improvement (p=.004). For balance, the BBS was investigated, for dance vs. exercise, dance improved significantly over exercise (p=.002), this was also seen for dance vs. no intervention (p=.02). For freezing of Gait, both dance vs. exercise and no intervention showed no difference between groups (p>.05), this was also the case for the 6MWT and velocity. For the PDQ-39, both Hackney & Earhart (2009) and Volpe et al. (2013) were included in the meta-analysis. Dance was found to be statistically superior than no intervention at improving quality of life (p=.01). This meta-analysis showed significant improvements for a number of outcome measures, specifically BBS, UPDRS III and PDQ39, which suggested improvements in balance, disease severity and quality of life. However, a major drawback of this meta-analysis was that there were only two

studies included for each outcome measure. Therefore, making any strong claims from this meta-analysis is difficult. The authors looked at a number of measures and compared dance vs. exercise and dance vs. no intervention, which cut down the sample size for each outcome measure. The meta-analysis appears too specific for the number of studies available on this topic.

Shanahan et al. (2015) also conducted a meta-analysis investigating the role of dance on the symptoms of PD; this is more substantial than the previous meta-analyses. Outcomes of interest for this analysis included the BBS, UPDRS III and TUG. Thirteen studies were included in the meta-analysis (Batson et al., 2014; Duncan & Earhart, 2012; Foster et al., 2013; Hackney & Earhart, 2009;2009b; 2009c;2010; Hackney et al., 2007; 2007b; Heiberger et al., 2011; Marchant et al., 2010; McKee & Hackney, 2014; Volpe et al., 2013). For the BBS, UPDRS III and TUG, five studies were included in the analysis, all of which showed that results favoured dance over control or other intervention. No p values for these meta-analyses were reported, although Forrest plots show confidence intervals do not intersect 0 and therefore showed an overall favour for dance over no intervention. The authors did suggest however that due to the heterogeneous nature of the previous research, that any firm conclusions should not be drawn from this analysis and future research is needed to investigate this topic further. Overall, this analysis supports the previous research that has found improvements in balance and disease severity.

Lötzke, Ostermann, and Büssing,(2015) conducted a recent meta-analysis on the effect of argentine tango in people with PD. This meta-analysis focused solely on studies using argentine tango as an intervention. Seven studies met the researchers inclusion criteria and were included in the quantitative meta-analysis. The outcome measures investigated included motor severity, as measured by the UPDRS III, balance, as measured by the mini-BESTest and BBS, gait as measured by the TUG and 6MWT and Freezing of gait, as measured by the FOG.

A significant improvement following argentine tango was found on motor severity and balance. Interestingly within gait, there was a significant improvement for the TUG, which was not seen in the 6MWT. There was no significant changes observed for freezing of gait. Meta-analyses ranged from between three and six studies within each outcome measure. One limitation with this meta-analysis is that only one of the studies included in the analysis was not from the same research group (Romenets et al. 2015). This meta-analysis suggests that Argentine tango can be beneficial for motor severity, balance and aspects of gait. There was no evidence to suggest that freezing of gait or non motor symptoms of PD can be improved following argentine tango interventions.

These five meta-analyses have begun to investigate the role of dance on the symptoms in more detail. However, there are limitations with each of these. Both DeDreu et al. (2012) and Tomlinson et al. (2013), did not focus exclusively on dance for PD and therefore their results cannot give any definite answers to the question, is dance beneficial for those with PD? Both Sharpe & Hewitt (2015) and Shanahan et al. (2015) investigated the effects of dance on PD exclusively. Sharpe and Hewitt (2014) exclude a number of papers, and the final meta-analyses included only two papers. At the time of writing there are many more research studies published in this area. This is also the case for Shanahan et al. ,although this paper was published this in 2015, there are now subsequent studies that could be analysed in a meta-analysis on this topic, including Blandy, Morris and Beevers, (2015), Hashimoto, Takabatake, Miyaguchi, Nakanishi and Naitou (2015), Romenets, Anang, Fereshtehnejad, Pelletier and Postuma (2015), and Batson Migliarese, Soriano, Burdette and Laurienti (2014). These additional papers have been published since this study (Shanahan et al., 2015) and could potentially be included to give the meta-analysis further statistical power. The final meta-analysis investigated the effect of argentine tango on a number of outcome measures. This analysis found significant improvements for the UPDRS III, miniBESTest, BBS and TUG. The natural progression from this is to investigate whether dance as a whole (including all the different forms explored previously) has a beneficial effect on these outcome measures. Therefore, the

current study will conduct this comprehensive meta-analysis into a number of physical and psychological outcome measures.

2.4.8 General limitations of the research

There are a number of issues that the previous research raised in their methodologies, findings and conclusions.

For Hackney, Kantrovic, Levin and Earhart (2007) and Hackney, Kantrovic and Earhart (2007) there is a significant methodological issue that may have a negative impact on the results of the study. For both these papers, comparisons of dance and exercise were investigated. The two groups, exercise and dance may differ in levels of physical activity, as intensity was not measured. It is therefore unsurprising that the PD tango group showed potentially greater benefits from the intervention as they were participating in more movement than the exercise group. It stands to reason that the participants in the tango group would show a greater improvement in mobility and balance as they have been using these techniques within the class. Is it simply a more vigorous movement that is causing an effect rather than the dancing? More research is needed to dissect out the specific mechanisms underlying these effects. The effort/expenditure of both classes were not measured and therefore it is unknown how they compare quantitatively. This is not only a point for this study, but studies comparing differing dance styles and exercises should be measuring the intensity of classes before claiming that one intervention is superior than another.

Clearer reporting of studies is also required. A number of papers described above have been published separately whilst focusing on different aspects of the same study. This is first seen in Hackney, Kantrovic, Levin and Earhart (2007) and Hackney, Kantrovic and Earhart (2007) in which these studies focused on different outcome measures in different papers. This is not the only difference, for one study the non-PD group data is reported and the other it is not. This type of reporting was also seen in Hackney & Earhart (2009) and (2009c) and Hackney & Earhart (2009d) and Hackney & Earhart (2010). At first glance, the

number of research studies investigating the effect of dance on PD is greater than the actual number of research studies.

The research previously has focused on comparing different dance styles and durations etc. A number of dance styles have been used when investigating the effects of dance classes on PD. Hackney & Earhart (2007,2009,2010) have tended to use the Argentine tango as the form of intervention. This has been compared with American ballroom (2009b) and contact improvisation (Marchant, Sylvester & Earhart, 2010). This decision has been explained in Hackney's PhD dissertation (2009) that describes how the Argentine tango targets specific areas of movement that can be the most beneficial for those with PD. Areas of benefit include balance, bradykinesia, stride length, turning, multitasking, backward walking and freezing of gait. The subsequent research has suggested that a range of other forms of dance can also be beneficial for those with PD and it is not only tango that can bring about positive physical and psychological changes. The research has begun to investigate some of these key factors, such as the role of exercise (Hackney & Earhart, 2007a;2007b) but this needs to be taken further to understand this topic more thoroughly.

The number of participants in each study, and lack of control groups in the research does limit the conclusions that can be drawn from the previous literature. Many of the studies described in this literature review lack statistical power due to the low sample sizes and therefore changes following these interventions are difficult to generalise. This is also the case for the lack of control and other intervention groups. It is unknown in many of these studies whether it is actually dance that is providing benefits for participants or simply that participants are involved in research and feel better as a consequence. There are studies that have found dance superior in results in comparison to exercise, although these have tended to have their own methodological issues, as described above (Hackney et al., 2007a,b). In order for these findings to be stronger further, higher quality research is required.

In order to understand what form of dance may be more or less helpful for those with PD, it is important to understand the potential mechanisms by which dance has an effect on the symptoms. Suggestions have been made within some discussions of the previous research, but this needs to be investigated further. Are there particular aspects of the dance that have been shown to be more beneficial, for example physiological (exercise/effort), psychological (social) benefits and practice of specific movements.

2.4.9 Rationale: Why should dance be a useful intervention for those with PD?

A number of mechanistic explanations have been put forward to explain the positive effect dance appears to have on those with PD. These include cognitive, musculo-skeletal and brain based explanations. No empirical research has been conducted into the mechanisms for why dance would have a beneficial effect on any aspects of PD, therefore mechanistic explanations described below are speculatory.

Improvements in symptoms related to increased activity have been out forward as a reason for observed improvements (Hackney & Earhart 2007;Hackney & Earhart 2009; Earhart 2010; Duncan & Earhart 2012) in terms multitasking and controlling physical movements. Walking and stride length were found to improve in Hackney & Earhart (2009) to which the authors suggested this is due to more attention being focused towards controlling movements specifically to fit the dance. The nature of the dance involved a variety of different movements, remembering steps and synchronising to the beat. Hackney & Earhart (2007) described this multitasking as being involved in the improvement of symptoms.

Heiberger et al. (2011) suggested further theories into mechanisms of dance and PD. The mirror neurone system is discussed with reference to improved motor movement. Mirror neurones are activated when observing and imitating another person. The researchers propose that motor plans are stored in the brain through imitating motor movements from the dance teacher and others around them. This activation of mirror neurones leads to an improvement of

physical symptoms, however this study does not expain how this mechanism would cause a benefit outside of the classes. Heiberger et al. (2011) also described the role of the dance sessions being an enriched environment, that involves physical movement, emotional responses, audio cues and memory. This environment may promote brain plasticity by increasing neurotrophic factors (Kattenstroth et al., 2010). Heiberger et al. (2011) also suggested that dance can increase serotonin levels, causing those with PD to feel better immediately after the session and also improve body awareness.

These explanations appear to fit within the biological basis of PD described previously. It would be predicted that the areas in the brain that show a deficit in function in those with PD, can benefit from activities that stimulate them. It may be the case that the little function that is left within these areas can be activated and increased function (or perhaps slower degeneration) can be gained by using them more regularly. This however, would not explain the short term benefits of dance. It is important to note that slower degeneration has not been demonstrated following dance. Another explanation could be that dance is helping to reroute information instead of these damaged areas and therefore improving function in that way. The other explanations in all likelihood help in improving symptoms, however they do not answer what the key mechanisms are within the brain. Increases in serotonin due to the reduction of depression and anxiety, multitasking and enriched environments could all have a beneficial effect on those with PD.

The mechanisms that describe neural changes begin to offer some explanations for why dance may be beneficial for those with PD. The most likely explanation for benefits observed in the literature are the use of external cues. This is also the most common explanation discussed in the text (Duncan & Earhart, 2011; Hackney & Earhart, 2009a, 2009b, 2010; Heiberger et al., 2011). Hackney and Earhart (2009a) discusses the role of both auditory and visual cues in tango dance classes. Auditory cues are described in terms of musical beat and visual cues of partners movements. The authors also suggest tango movements are mimicking cueing techniques used for rehabilitation in PD i.e. stepping over

partners feet, which is also used as a cue when someone with PD is freezing. Earhart (2010) suggested that these cues may bypass the 'dysfunctional loop' between the basal ganglia and SMA, potentially utilizing the thalamus in those with PD. This is the most common explanation given for the effect of dance on PD.

This theory would suggest that prolonged dancing would stimulate the basal ganglia and in turn improve motor symptoms and walking ability.   This theory is based on the research conducted by Brown et al. (2006) that found completing tango steps increased activation in the Putamen (see chapter 1 for details of deficits in the PD brain). In this paper, amateur tango dancers completed a number of tango dance steps whilst in a PET scanner. This involved completing the steps to rhythmic tango music, irregularly timed tango music and no music. Whilst completing these activities, participants underwent a PET scan. This involved listening to music through earphones, with the participant's head kept still using a facial mask, this was to keep the head still whilst the scan was taking place. Participants were also asked to keep their body as still as possible. Two scans were taken of each of the six tasks, each lasting 50 seconds. Participants were injected with a bolus immediately prior to the scan for the PET scan to distinguish activation of different areas of the brain. Results suggested that there were differences in brain activation between participants conducting the tango steps to both a regular and irregular tango beat. The basal ganglia, more specifically the putamen, were activated to rhythmic movement. This suggests the putamen is involved in the selection of movements that are strongly predictable, as dancing to a beat (Brown et al. , 2006).

These findings have been cited as suggesting that dance can be beneficial for motor symptoms of PD due to the deficit in these areas of the brain. It is well noted that those with PD have difficulty in keeping to a beat and often lose their internal rhythm. The findings of Brown (2006) would indicate that the areas in which those with PD have a deficit, are the very ones that are able to select movement s to a predictable rhythm. When those with PD dance, these areas are stimulated, leading to motor improvement.

It has been suggested that dance may be able to reorganise neural processes (Sacco, Cauda, Cerliani, Davide, 2005). This study investigated changes in brain activation whilst participants imagined walking in an fMRI scanner. Participants were split into an experimental or control group, both groups were scanned one week apart and imagined walking at normal speed in a parallel line. In the experimental group, participants completed five days of one hour tango classes. The control group showed no differences in activation from pre to post. Differences were, however, observed for the experimental group. There were significantly greater activation of premotor and supplementary pre motor areas (involved in the anticipation of action) than pre training scan. This finding suggests that changes in motor circuits can occur following dance. This is discussed in a number of papers exploring the role of dance on the symptoms of PD (Earhart, 2009; Hasimoto et al, 2015; Hackney & Bennett, 2014; Mandelbaum, 2014). This study is linked to the research suggesting that focused attention on walking steps within the tango can lead to an improvement in walking ability. It should be noted that this study focused participant's attention on the walking movements and foot placement throughout over other aspects of the dance (arm and head placement etc).

Although these two imaging studies may have their weaknesses, they do suggest that whilst dancing, there is increased blood flow to areas of the brain, which are known to have deficits in PD. It is not known what effect this may be having on these areas as no studies have been conducted. Until a research project investigates the stimulation of these areas following dance in those with PD, it is difficult to determine whether these areas even do match the pattern of those without the disease following dance. It makes sense that there could be beneficial effects of dance through the stimulation of the basal ganglia region of the brain, although to what extent is unknown.

Previous research has suggested that rhythmic auditory stimulation (RAS) can have a beneficial effect in walking on those with PD (Thaut, McIntosh, Rice, Miller, Rathbun & Brault, 1996; McIntosh, Brown, Rice & Thaut, 1997). McIntosh

et al (1997) suggested that those with PD were able to modify their stride length and pattern to match a beat. Improved gait, stride length and cadence were also seen after three weeks RAS home based training. This involved walking to rhythmically accentuated instrumental music with increasing tempo over the three weeks. Again, this explanation of external cues has been used to describe why those with PD may have an improvement in symptoms following dance (Blandy et al, 2015; Duncan & Earhart, 2011; Hackney & Earhart, 2007;2009a; 2009b; Westheimer, 2015). External cues such as auditory (musical rhythm), visual (dance teacher), sensory (partner) and cognitive (memory of steps) may be able to bypass the basal ganglia all together in PD (Hackney & Earhart, 2009). Using external cues from a number of sources may be able to access areas of the brain through different neural pathways rather than the basal ganglia (Hackney & Earhart ,2009).

2.4.10 Conclusions

Overall, the previous research has suggested that there may be some physical improvements following dance sessions. Differences in findings between studies may be due to varying dance styles and durations of intervention. These findings have lead to the conclusion that changes following dance sessions are not clear-cut and require further exploration.

The literature gives us an indication that dance may be beneficial for those with PD. The research suggests that that various forms of dance have shown positive effect on a number of physical and psychological outcome measures (Hackney & Earhart, 2009abcd). There are a number of issues with the previous research, as discussed in the chapter. It is difficult to make any firm predictions from the research because of these.

Immediate changes following dance sessions require further investigation, as do studies having multiple assessment time points over a long scale study. The addition of this research with large sample sizes would help us to further understand the effect of dance on PD. The mechanisms which are involved in the

changes following dance are also crucial for the understanding of why dance appears to have a beneficial effect for those with this disease.

Research questions**:**

  1: Are the findings of previous research replicable? The findings from the previous research studies are not clear cut. Studies have tended to use a number of physical outcome measures pre and post assessment,. Are we able to replicate the same physical improvements following dance in people with PD?

  2: Are there psychological improvements following dance? The literature has heavily focused on physical changes following dance, with only one study investigating changes in quality of life following dance (Hackney & Earhart, 2009c). Are there other psychological changes that are apparent after a dance intervention? Are mood, cognition and quality of life affected by dance in those with PD?

2.5 Structure of the Thesis

- **Chapter 3: General Methods**

This chapter outlines the various clinical assessments that were used throughout the programme of research. Each test includes details of the procedure and scoring. The chapter also outlines the recruitment processes that were used in each of the studies.

- **Chapter 4: Meta-analyses**

A meta-analysis was conducted on the previous dance research that focused on motor changes in those with PD. This analysis was conducted due to inconsistencies between the previous literature. A meta-analysis was conducted on the main outcome measures used within the previous research, Unified Parkinson's Disease Rating Scale III (UPDRS III), Berg Balance Scale (BBS),Timed Up and GO (TUG), The Six-Minute Walk Test (6MWT) and Parkinson's Disease Quality of Life Scale 39 (PDQ-39). Twelve papers were included in the final analysis. Findings suggested that

improvements for UPDRS III, BBS and TUG were significant for the pooled papers. No significant effects were seen for 6MWT and PDQ-39.

- **Chapter 5: Study one – Social dance**

This study explored the physical and psychological effect of dance on those with PD. This study aimed to build on previous literature by using a number of the same physical tests as used previously, as well as including novel psychological tests to explore changes in the group following dance. This study included four structured forms of dance; bollywood, tango, music hall, cheerleading. The final two weeks included a party dance and recap of the previous dances learnt. Each of these dances was completed for two weeks and then a new form of dance was introduced, this intervention lasted for ten weeks. No changes in balance were observed following the sessions. Improvements in quality of life were seen, but this time in the communication dimension. Previous research has failed to focus on psychological changes following dance, this study was the first to explore both short and long term mood following dance. Significant improvements were observed in mood, both immediately after the classes (short term) and overall (long term) following the dance intervention. There were no changes in divergent or convergent thinking at post assessment.

- **Chapter 6: Study two – mood in different social groups**

Study two was devised to explore differences in mood of those with PD participating in different social activities. This study compared the mood of those participating in dance sessions with those not completing any social activities, completing exercise classes and other social activities in a real world setting. This study found no differences in mood between these groups. This study suggested that mood levels of those completing dance sessions in a non laboratory setting, showed no global mood differences from those completing no recreational social activities, exercise classes or other activities.

- **Chapter 7: Study three – Short term changes after movement to music**

Study three explored the effect of music and movement on immediate mood changes in a home based setting. This study explored whether movement to music without the social aspect of a group class, had an effect on short term mood levels. The study investigated whether watching or using a music and movement DVD for 30 minutes could bring about mood changes in those with PD within their own home. It was found that significant mood improvements were seen following this intervention, suggesting that a short home based resource could improve mood. This study suggested that following an at home exercise to music DVD improved mood in those with PD. These findings showed that movement to music without the dance and socialisation factors continue to have a short term effect on mood.

- **Chapter 8: Study four – Movement to music intensive study**

This study built on the findings of study three using the music, movements and a combination of music and movement to explore the role of these components more specifically. This study was conducted in participants' homes, with participants listening to 30 minutes of music, completing 30 minutes of movement and both of these together in a cross over design. Participants completed these tasks within their own home with assessments before and after each intervention. Findings showed no differences between each of these conditions for self reported symptoms, mood and quality of life. This suggested that mood levels following intensive exercise, music listening and a combination of both music and movement together showed no change compared with baseline.

- **Chapter 9: Study five – Short term mood changes after watching dance**

This study predominantly aimed to further investigate the socialisation effects that may have occurred in study three. Within study three, participants completed the DVD on their own, but with the researcher

present. This social effect of the researcher may have had an effect on mood changes and demand characteristics. The aim was to run a similar study to study three, using stimuli designed to create no changes in mood, except having the researcher present. The stimuli was a DVD for participants to watch showing thirty minutes of improvised dance clips. Significant mood improvements were found after watching dance, but a different pattern of results to those seen in study three. This would suggest that the social effect of the researcher being present was having an effect on mood, but completing music and movement exercises provided greater improvements. These findings show that there may be more than just exercise effecting mood in this programme of research.   The effect of the researcher being present whilst participants completing the research has been shown to play a key role in changes in mood in this study.

- **Chapter 10: Discussion**

This final chapter includes a general discussion of the thesis and critically evaluates this programme of research. This chapter discusses the current research in light of recently published research, novel findings and contribution to the field.

Chapter 3: General Methods

This chapter will outline the general methods that were used in the programme of research. This includes details of the various physical, psychological and cognitive tests that were used throughout the studies as well as details of recruitment procedures and materials. For each of the tests details of the procedure and scoring can be found.

All studies included a range of demographic questions and required particpants to list all medications they are taking. This information is used, where appropriate for analysis purposes.

3.1.1 Screening Tests

1. Physical Activities Readiness Questionnaire (PAR-Q)(Thomas, Reading & Shepard, 1992): The PAR-Q is used as a screening tool to ascertain whether a change in physical activity is safe. If participants answer yes to one or more questions, they should consult their doctor before increasing their physical activity level.

2. The Healthy Physical Activity Participation Questionnaire: A self report measure for perceived fitness levels and how often participants complete physical activity. This is used to gauge the fitness level of the group and at which level to pitch the classes. Data from this questionnaire was only available to the dance teacher.

3. Falls History Questionnaire: Participants indicate the number of falls and near misses they have had in the past 12 months.

4. Dance History Questionnaire: Participants indicate whether they have danced before and to what level.

5. Mini Mental State Examination (MMSE) (Folstein, Folstein & McHugh, 1975): This is a screening tool used to assess the mental status of Participants. This 11-item tool testing Orientation (recalling the time/place), Registration and Recall

(recalling 3 objects), Attention and Calculation (Counting backwards from 100 in seven's) and Language (following commands and reading aloud). A score of 23 or below indicates cognitive impairment.

3.1.2 Psychological Tests

6. Activities-specific Balance Confidence Scale (ABC) (Powell & Myers, 1995): For each of the activities outlined in the 16 item scale, participants are required to rate confidence (0-100%) that they will not fall. A total self confidence score is summed and used as a dependent variable.

7. 8. Falls Efficacy Scale (FES) (Tinetti, et al, 1990): This scale measures fear of falling when conducting a number of everyday activities. This is measured from 10-100. A score of 100 would indicate that the participant believes they will definitely fall if they completed the tasks.

8. Parkinson's Disease Quality of Life Scale (PDQ-39) (Peto, et al, 1995): This is a 39 item questionnaire that measures Quality of Life specifically for those with PD. It measures 8 subsections within quality of life as well as a total quality of life score, Mobility (10items), Acitvities of daily living (6 items), Emotional Wellbeing (6 items), Stigma (4 items), Social support (3 items), Cognition (4 items), Communication (3 items) and Bodily discomfort (3 items). Participants are asked to indicate the frequency of each event by selecting one of 5 options (likert Scale): never/occasionally/sometimes/often/always or cannot do at all. The scores on each dimension are transformed and range from 0-100, 0 would indicate highest level of quality of life and 100 would indicate lowest level of quality of life.

$$\frac{\text{Total score for dimension}}{\text{Max score per question (4) X number of questions for that dimension}}$$

Any missing data will inhibit scoring of that dimension, this will also prevent a Summary Index (SI) score being created for that participant. The Summary Index

is an overall score for the PDQ-39 scale, this is calculated as the mean of each dimension.

9. Profile of Mood States Questionnaire (POMS) (McNair, et al, 1971): A 65 item questionnaire measuring 6 mood states, Depression-Dejection, Anger-hostility, Vigor- Activity, Tension-Anxiety, Confusion-Bewilderment, Fatigue-Inertia. A higher score on each of these categories indicates higher level of that mood state. (A higher score indicates a more negative mood for all dimensions except Vigor). A total POMS score is calculated (POMS TMD). Participants are asked to indicate how often they feel each of the emotions (likert Scale): not at all/ a little/ sometimes/ quite a bit/ extremely.

Table 3.1 Mean (SD) Geriatric Norms for Males and Females on the POMS questionnaire (Nyenhuis et al.,1999)

	Tension-Anxiety	Depression-Dejection	Anger-Hostility	Vigour-Activity	Fatigue-Intertia	Confusion-Bewilderment
Males	4.6 (3.7)	4.3 (5.4)	3.9 (4.5)	22.3 (5.7)	5.0 (4.9)	3.9 (2.9)
Females	6.9 (5.9)	6.9 (7.5)	4.7 (4.9)	20.6 (6.2)	6.9 (5.6)	4.9 (3.8)
Total	5.9 (5.2)	5.8 (6.7)	4.4 (4.7)	21.3 (6)	6.1 (5.4)	4.5 (3.5)

Norms for each of the dimensions can be seen in table 3.1.

10. Brunel University Mood Scale (BRUMS) (Terry & Lane, 2003): This is a modified version of the POMS-A, a 24-item scale that has the same subscale dimensions as the POMS (Depression-Dejection, Anger-hostility, Vigor- Activity, Tension-Anxiety, Confusion-Bewilderment, Fatigue-Inertia).

3.1.3 Cognitive Tests

11. Alternative Uses Task (AUT) (Guilford, 1967): This task measures divergent thinking. The task requires participants to think of as many alternative uses as they can for an item (in this case a brick and a newspaper). The participants have three minutes in which to do this. Each participant has a different object at pre and post assessment for counterbalancing, e.g. alternative uses for a Brick at Pre

testing and alternative uses for a newspaper at Post testing.   From this data, a score of verbal fluency and flexibility can be computed.

Fluency: The number of valid uses the participant has come up with.

Flexibility: The number of categories the responses belong to.

12. Abbreviated Torrance Test for Adults (ATTA) (Goff and Torrence, 2002): This is another measure of divergent thinking. Participants are given a sheet of paper with either 9 triangles or 9 circles on it. The participants are then required to draw as many pictures as they can incorporating these objects in three minutes. From this data, fluency, originality, flexibility and elaboration scores can be calculated

Fluency: The number of valid uses the participant has come up with.

Flexibility: The number of categories the responses belong to.

Elaboration: The extra detail used on the images i.e. all detail that is not essential in identifying the image.

Originality: How original is the picture compared to previous research?

13. Mental Rotations Task (MRT) (Shepard & Metzler, 1971): The mental rotations task is a measure of convergent thinking. This task is conducted on a computer. Participants view an image of two objects and have to decide whether they are indeed the same object but have been rotated. The participants mentally rotate the object to identify whether they are the same. From this data, the number of correct responses and reaction times for the correct responses are compared pre and post testing.

14. Lexical Decision Task (LDT) The lexical decision task is also a measure of convergent thinking. In this task, a string of letters flash up on a computer screen, participants are required to identify whether they are a word or a non word. The number of correct responses and reaction times for the correct responses are compared pre and post testing.

3.1.4 Physical Tests

15. UPDRS 1 & II (Fahn & Elton,1987): These are the first two parts of the UPDRS. The UPDRS I contains four questions with regard to mentation, Behaviour and Mood. This section includes 4 questions with a total maximum score of 16. For UPDRS II, there are 12 questions with a maximum score of 52.

16. UPDRS III & IV (Fahn & Elton, 1987): The UPDRS IV deals with complications of therapy, such as Dyskinesias.The UPDRS III is a physical examination of a number of PD specific symptoms, such as rigidity. UPDRS III includes 13 questions and a maximum score of 108. UPDRS IV includes 10 questions.

17. The MDS-UPDRS Ib & II (Goetz et al. , 2008) is a revised version of the UPDRS (Fahn & Elton, 1987). MDS-UPDRS Ib is concerned with non motor aspects of daily living, such as sleep problems and pain. MDS-UPDRS II is concerned with the motor aspects of daily living, such as tremor, handwriting and speech etc. The scale ranges from 0- 28 for the MDSUPDRS Ib and 0-52 for the MDS-UPDRS II. Higher scores indicate higher level of problem.

18. Berg Balance Scale (Berg, et al, 1995): The Berg Balance Scale is a 14 item scale that measures balance. Scores range from 0 – 56, with 56 indicating no balance issues. A five-point scale, ranging from 0-4. "0" indicates the lowest level of function and "4" the highest level of function. Scores 41-56 = low fall risk, 21-40 = medium fall risk and 0 –20 = high fall risk.

19. Timed Up and Go test (TUG) (Mathias, et al, 1986): This is a standardised test designed to measure basic mobility. This test measures the speed and number of steps a participant takes to rise from a chair, walk 3 metres, turn, walk back and sit down in the chair. The TUG involves the participant being timed while they rise from a chair, walking three metres, turning around and returning to sitting in the chair. The time it takes for participants to complete the task acts as the dependent variable. The TUG measures postural control and balance by getting out of a chair unaided, walking, turning and sitting back in the chair. It has been

found to correlate well with measures of balance and gait (Podsiadlo & Richardson, 1991).

Neurologically intact adults who are independent are expected to complete the test within ten seconds (Podsiadlo & Richardson, 1991).

Table 3.2. Guidelines for function (Podsiadlo & Richardson, 1991)

Time Taken	
< 10 seconds	Freely independent
< 20 seconds	Independent in basic tub or shower transfers, able to climb stairs and go outside alone
< 30 seconds	Dependent in most activities.

Reference times have also been suggested for healthy elderly adults, Bohannon (2006) conducted a meta-analysis on 21 studies investigating the TUG in older adults and proposed norms for different age groups. It was suggested that 60-69 year olds should take on average 8.1 seconds to complete the task. For 70-79 years old, this increased to 8.2-10.2 seconds. For those 80-99, the average range was 10-12.7 seconds.

20. The Six-Minute Walk Test (6MWT) (Enright, 2003). For the 6MWT, participants are required to walk as far as possible in six minutes, this is often completed on a treadmill or down a narrow walkway. Normative data for the elderly can be seen below (Bohannan, 2007).

Table 3.3 Normative data for the 6MWT

Category	Mean distance (95% CI)
Men 60–69	560 (511–609)
Women 60–69	505 (460–549)
Men 70–79	530 (482–578)
Men 70–79	490 (442–538)
Men 80–89	446 (385–507)
Women 80–89	382 (316–449)

These data show that in six minutes the elderly are able to walk a significant distance during the task. Although, a study by Canning, Ada, Johnson and McWhirter (2006) suggested that those with PD walked a significantly shorter distance than elderly controls (p=.01)

21. Hoehn & Yahr Staging, (Hoehn & Yahr, 1967): This is a 5 point scale in which individuals with PD are scored due to disease severity. This ranges from 1-5. With 1 indicating main symptoms are present (tremor and muscle stiffness) but are contained to only on one side of the body, and 5 indicating wheelchair or bed bound.

22. Mini BESTest, Franchignoni, et al (2010): The Mini BEStest is a 14 item scale that also measures balance disturbances. This scale has been shown to be correlated with disease severity and has no floor or ceiling effects. In this respect it may be a more useful tool to measure change in participants that are already quite high functioning at the pre testing assessment.

3.2 Recruitment procedures

Participants were recruited through a number of channels throughout the programme of research. Participants with PD were predominantly recruited through Parkinson's UK (PUK). The researcher attended local PUK support groups (within a 1.5hour driving radius) and PD specific activity groups for recruitment purposes. Details of each study were also send out to the PUK Research support Network and publicised on their website. Details of active

studies were also included on the University website. A recruitment poster was also used for study 1, see below.

Figure.3.1 Recruitment Poster

Online forums were also used to publicise research such as

- Allaboutparkinsons.com
- Craigslist
- Backpage.com
- Social networking websites
    - Facebook
    - Twitter
- Local message boards
    - Ware online
    - Stevenage online
    - Hertford online
- Over 50's online forums
    - Fiftyplus.com
    - Healingwell.com
    - Buzz50.com
    - Over50's.com

Previous participants were also send information of each study and encouraged to pass on recruitment information to any interested parties.

Chapter 4: A meta-analysis of dance for PD papers published up to 2016

4.1 Introduction

The aim of this chapter is to conduct a comprehensive meta-analysis into the effects of dance for those with PD. The chapter will explore the quality and availability of key papers that have been used to support the idea that dance is beneficial for both physical and psychological symptoms of the disease. Meta-analyses into this area have been published recently (Lötzke, Ostermann, & Büssing, 2015; Shanahan, Morris, Bhriain, Saunders & Clifford, 2015; Sharpe & Hewitt, 2014). These studies have focused on specific forms of dance (Lötzke, et al. 2015) or comparing different groups (Sharpe & Hewitt, 2014). The current meta-analysis aims to look more broadly at the effect of dance in general, rather than focusing on one specific form of dance on common outcome measures used in the research. This will be compared with previous meta-analyses to determine the effectiveness of this type of intervention.

4.1.1 Rationale

Since the first paper into the effects of dance on the symptoms of PD was published in 2007 (Hackney & Earhart, 2007), there has been a steep increase on the number of papers investigating this research topic. To date, 48 papers have been published on the effect of dance on those with PD, including reviews, meta analyses and experimental research. These papers include all studies that have discussed the effect of dance on PD, including dance therapy papers, physiotherapy and qualitative research. The empirical research has investigated a range of different outcome measures such as balance, gait, disease severity, mood, quality of life and cognition. More recently there has been five meta-analyses and seven reviews discussing these papers (DeDreu, Van der Wilk, Kwakkle and Wegen, 2012; Earhart, 2009; Hackney & Bennett, 2014; Tomlinson et al, 2013; Shanahan, 2015; Lotzke, 2015). However, some past meta-analyses have not focused solely on dance and its effect on PD. DeDreu et al. (2012) investigated the role of music therapy on walking ability, balance and quality of

life. This included a handful of the papers investigating dance and PD but this was not the main focus. This is consistent with Tomlinson et al. (2013) compiled a comprehensive Cochrane review of the effect of physiotherapy and a number of other activities on the symptoms of PD. To date, meta-analyses and a number of reviews of the dance and PD literature have been published.

4.1.2 Objectives

Main objectives of the meta-analysis are to explore the questions:

- Does dance produce a change in balance scores?
- Does dance lead to a change in disease severity?
- Does dance bring about a change in walking ability?
- Does dance have an effect on perceived quality of life?

4.2 Methods

4.2.1 Inclusion/Exclusion criteria

Once the initial list of papers had been compiled, inclusion/exclusion criteria were applied. This is to ensure that only the most relevant papers for the topic were included in the meta-analysis.

Inclusion/ Exclusion criteria:

- Pre and post assessments greater than one week apart
- Experimental papers
- No case studies
- Outcome measures relevant to the meta-analysis aims
- Sufficient information to calculate an effect size
- Good level of methodological quality, as measured by the Physiotherapist Evidence Database scale (PEDro scale) (Verhagen et al. 1998)

4.2.2. Information sources and search terms

The first step of the Meta-analysis was to conduct a literature search to investigate the published research. A number of strategies were employed in order to obtain the relevant publications. Literature searches were conducted by

searching Boolean operators: ISI Web of Knowledge, PubMed, Scopus and Google Scholar with the search terms, outlined below:

Search Terms:				
Music	Dance	Dancing	Exercise	Quality of life
	Parkinson's	Parkinson's disease	Balance	Tango
Disease severity	PD	Ballroom	Argentine Tango	

Titles and abstracts for each of the search engine results were examined for relevance. Those not including information regarding the effects of dance and PD were discarded. Abstracts of relevant papers were obtained and where an email address was supplied, those were contacted to provide data.   Reference lists were also targeted to check for relevant papers. A total of 48 papers were selected into the initial pool.

4.2.3 Data collection Process

Means, standard deviations, p values and effect sizes were obtained where possible from published papers. A number of papers did not include all four of these pieces of information and therefore authors were contacted to ensure all relevant information was available. Effect sizes were calculated using Cohens D. Cohens d has been calculated using the pre and post mean and pre standard deviation. This has been described as the more conservative option of calculation from means and best practice for this statistical design (Field & Gillett, 2010). Effect sizes were calculated using the effect size generator 2.3.

4.2.4 Synthesis of results/ Calculating effect sizes

Comprehensive Meta-analysis software was used to conduct this meta analysis. Relevant data were extracted from the articles to be entered into the programme such as pre and post means, number of participants and p values.

The random effects model was used over the fixed effects model as it was a better fit with the current data. The random effects model does not assume

there is one true effect size within the studies, but that it may differ slightly due to uncontrolled aspects of the studies such as disease severity. The results are generalizable further than the final pool of studies. Relative weights given to each of the studies in the meta-analysis also differ between models. The random effects model an even weight distribution; whereas the fixed effects model gives higher weighting's to studies with larger sample sizes. In this meta-analysis where there are a number of small sample studies, the random effects model is a better fit.

For each of the studies, the effect size Cohens d was calculated throughout. Cohens d has previously been given thresholds to indicate size of effect (Cohen, 1988). The addition of 1.3 as a very large effect size was added later by Rosenthal (1996).
These thresholds should be used to interpret effect sizes, but should be used with caution and be comparable within the study context.

For studies that included pre and post means and a measure of variance but did not include the exact p value, these were estimated. For non significant studies .999 was entered. For those indicated by $p>.05$, .05 was estimated and for $p<.01$, .01 was used. Again this is the most conservative estimate when exact data were not available.

4.2.5 Risk of Bias

There are significant risks of cumulative bias across the papers included in this studies. Two of the main risk of bias include selective reporting and publication. As described previously, papers have tended to be salami sliced and there is a significant risk of selective reporting. When contacting authors to obtain data, authors were asked whether any other outcome measures were included in the study but were not published.

4.2.6 Publication bias

Publication bias is problem in all meta-analyses. Papers that report statistically significant findings are not only more likely to be published, but published more

rapidly and in higher impact journals which will have a bias on any meta-analysis. Publication bias is important for data that is not in the public domain, but also selective outcome reporting. Authors may have measured certain outcomes but did not include them in a paper because the results were not deemed statistically interesting. Publication bias was examined using the CMA programme and the fail safe N. This statistic gives the reader an estimate of how many papers with a non significant result or a negligible effect size (Orwins fail safe N) would be required to show an overall non significant result in the meta-analysis.

4.3 Results
4.3.1 Study Selection
Once the inclusion/exclusion criteria were applied the initial list of studies decreased to 12. This can see seen pictorially in Figure 4.1.
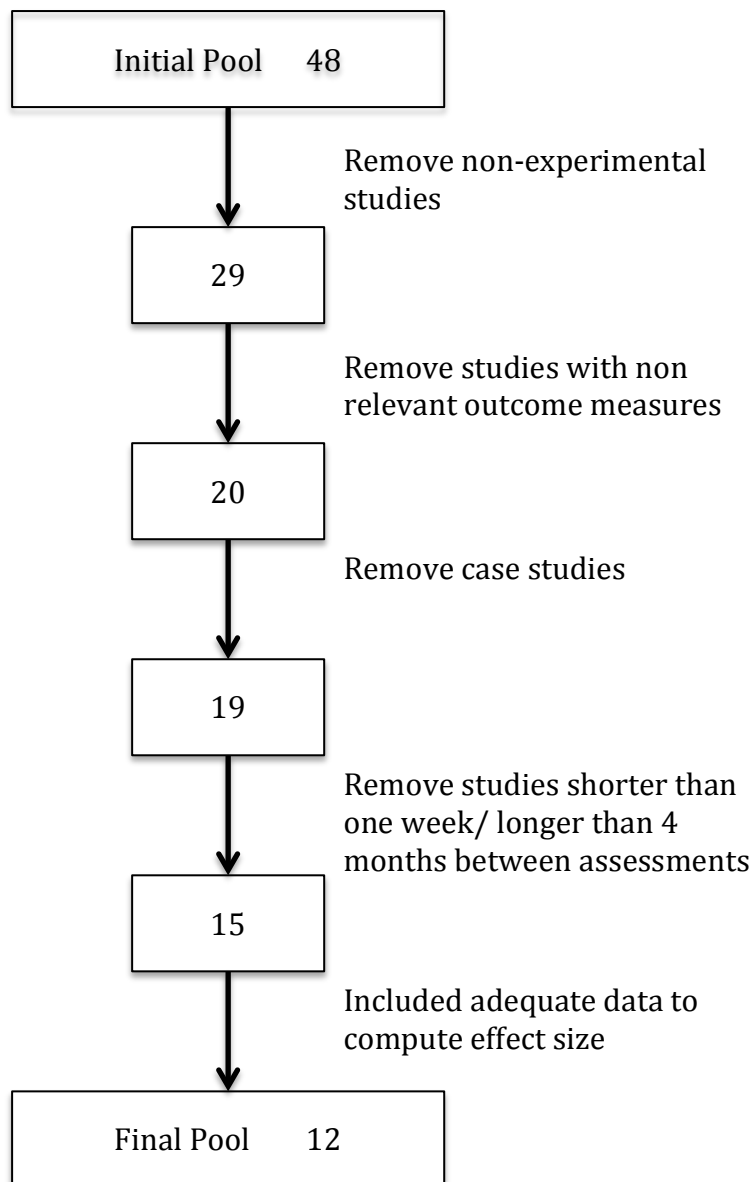
Figure 4.1 Flow chart showing the decrease in papers following application of the Inclusion/Exclusion criteria

Before starting the analysis – methodological quality was assessed to determine the strength of the data being used in the analysis. Quality was assessed on the final pool of studies using the PEDro score, out of a possible 11. Higher score indicate higher quality research (Maher, Sherrington, Hertbert, Moseley & Elkins, 2003). A score of higher than four indicates acceptable quality research. This method of scoring was previously used in the DeDreu et al. (2012) & Shanahan et al. (2015) meta-analyses.

Table. 4.1 PEDro scores for the final pool of studies

Article	Year	PEDro Scale											Total
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	
Hackney et al.	(2007)	1	1	0	1	0	0	1	0	0	1	1	**6**
Hackney & Earhart	(2009a)	1	1	1	0	0	0	0	0	0	1	1	**5**
Hackney & Earhart	(2009b)	1	1	1	1	0	0	0	0	0	1	1	**6**
Hackney & Earhart	(2009c)	1	0	0	0	0	0	1	1	0	0	1	**4**
Hackney & Earhart	(2009d)	1	1	1	1	0	0	1	0	1	1	1	**8**
Marchant et al.	(2010)	1	0	0	0	0	0	0	1	1	0	1	**4**
Duncan & Earhart	(2012)	1	1	0	1	0	0	0	0	1	1	1	**6**
McKee & Hackney	(2013)	1	0	0	1	0	0	1	1	0	1	1	**6**
Volpe	(2013)	1	1	1	0	0	0	1	0	0	1	1	**6**
Batson et al.	(2014)	1	0	0	0	0	0	0	1	1	0	0	**3**
Hasimoto et al.	(2015)	0	1	1	1	0	0	1	1	1	1	1	**7**
Romenets et al.	(2015)	1	1	1	1	0	0	0	1	1	1	1	**8**

1 = Eligibility criteria specified 2 = Random allocation; 3 = Concealed allocation; 4 = Baseline similarity 5 = Blinded subjects; 6 = Blinded therapists; 7 = Blinded assessors; 8 = less than 85% drop out; 9 = Intention-to-treat analysis; 10 = between-group statistics; 11 = Point estimates and variability

For all items, 0 indicates this was not present in the study, 1 indicates this criteria was satisfied.

These data show that for most studies, the methodological quality was above four, indicating an adequate quality study to be included on the meta-analysis. Due to the pre post nature of the study, in some cases with only one group, questions regarding between group allocation and analysis could not have been satisfied. Table 4.1. shows that Batson (2014) did have a score of three which is lower than the target score, however this paper will not be removed from the analysis due to its relevance to the research aims and outcome measures. The final pool of studies included in the meta analysis are described below:

69

Hackney, Kantrovic, Levin & Earhart (2007)

Two intervention groups of either tango or exercise completed twice weekly sessions of one hour over ten weeks. Pre and post assessments were completed before and after the sessions.

Hackney & Earhart (2009a)

A comparison of two intervention groups and one control group. The two intervention groups included participants either completing Argentine tango or waltz/foxtrot dance sessions over a ten week period. Participants completed 20 dance sessions, with twice weekly sessions for one hour. Pre and post assessments were completed before and after the intervention.

Hackney & Earhart (2009b)

An intensive Argentine tango intervention of two weeks was completed by participants for 1.5 hours a day, 5 days a week. Pre and post assessments were completed before and after the intervention.

Hackney & Earhart (2009c)

This study compared three intervention groups and a control group on quality of life measures. Participants completed either tango, waltz/ foxtrot, Tai chi or no intervention over a ten week period. Participants completed twice weekly sessions for one hour. Pre and post assessments were completed before and after the intervention. Hackney & Earhart (2009ac) are reporting the same experimental study.

Hackney & Earhart (2009d)

A comparison of partnered and non partnered tango dance sessions over a ten week period. Participants completed a pre and post assessment and also a follow up one month after the interventions concluded. Participants completed twice weekly classes of hourly dance classes.

Marchant, Sylvester & Earhart (2010)

A two week intensive contact improvisation intervention, with participants completing sessions for 1.5 hours, 5 days a week. Pre and post assessments were completed before and after the intervention.

Duncan & Earhart (2012)

A twelve month intervention comparing two groups, an Argentine tango group vs a control group of no intervention. Participants completed one hour per week for the entirety of the programme. Pre assessments were completed before the intervention, 3, 6 and 12 month assessments were completed throughout the study.

McKee & Hackney (2013)

A twelve-week intervention comparing education lectures and tango dancing. Participants completed 20 sessions of 90minutes of either of the intervention groups. Pre and post assessments were completed before, after the interventions, with a third follow up 10-12 weeks after completing the task.

Volpe, Signorini, Marchetto, Lynch & Morris (2013)

A six-month intervention comparing the effect of Irish dancing and physiotherapy. Participants completed weekly, 90 minute sessions and also had an 'at home' programme to practice the content of previous sessions.

Batson, Migliarese & Soriano (2014)

Two phase study, with the first being a dance intervention, the second an fMRI on one participant. During phase 1, participants completed pre and post assessments seven weeks apart, with thrice weekly dance sessions lasting one hour. Participants completed contact improvisation as their dance intervention.

Hasimoto, Takabatake, Miyaguchi, Nakanishi & Naitou (2015)

Twelve week intervention consisting of three groups, dance, exercise and no intervention group. Participants completed interventions once a week for sixty minutes, the no intervention group simply continued with their normal routines.

Romenets, Anang, Fereshtehnejad, Pelletier & Posthuma (2015)

Twelve week intervention of either tango classes or self directed exercise. Participants completed a once weekly class of sixty minutes in Argentine tango, the self directed exercise group were given information about exercises for PD and told to complete these exercises each day.

4.3.2 Study Characteristics

These papers all follow the same design, with a pre and post assessment before and after the intervention. Duncan & Earhart (2012) have assessments at three, six and 12 months, however the data from the three month time point will be used in this meta analysis in order to be comparable to the other research studies. A number of different outcome measures were used between these final papers. The most commonly used outcome measures between the studies will be used in the meta analysis. These are:

The Berg Balance Scale (Berg et al. , 1995) BBS
The Timed Up and Go (Mathias et al. , 1986) TUG
The Six Minute Walk Test (Steffen & Seney, 2008) 6MWT
The Unified Parkinson's Disease Rating Scale III (Fahn & Elton, 1987) UPDRS III
The Parkinson's disease quality of life (PDQ-39) scale (Peto et al. , 1995) PDQ-39

For any studies that reported using relevant outcome measures but did not include pre/post means or p values, authors were contacted in order to obtain the relevant data.

4.3.3 Results of individual studies

BBS

The below papers included the outcome measure pre and post the dance sessions.

Table 4.2. Mean Scores on the BBS with Effect sizes by study

Article	Date	N	Pre Mean	Pre (SD)	Post Mean	Post (SD)	Effect Size d	Sig.
Hackney et al.	2007	9	46.80	3.16	50.60	3.16	1.20	.010
Hackney & Earhart	2009c	12	47.80	3.20	50.60	3.50	.88	.021
Hackney & Earhart (W/F)	2009a	17	48.10	4.95	52.10	4.95	.81	.001
Hackney & Earhart (T)	2009a	14	48.10	5.24	52.00	2.99	.74	.001
Hackney & Earhart (N/P)	2009d	20	47.80	4.60	50.40	3.80	.57	.050
Hackney & Earhart (P)	2009d	19	45.20	7.80	48.40	7.60	.41	.050
Marchant et al.	2010	11	48.30	5.31	51.30	4.31	.56	.007
Volpe et al.	2013	12	36.08	9.20	46.08	6.75	1.09	.051
Hasimoto et al.	2015	19	51.1	3.5	55.1	1.2	1.14	.001

Effect sizes are shown in the format of Cohen's d. (W/F) indicates the Waltz/Foxtrot condition. (T) indicates the tango condition. (N/P) indicates the non partner condition. (P) indicates the Partner condition). For the BBS, an increase on score indicates an improvement in Balance.

The data shows that six papers use the BBS, with both Hackney & Earhart (2009a; 2009d) having more than one dancing experimental group. Both studies included two dance groups, these groups have both been included in the effect size tables to show differences between conditions.

Table 4.2 shows that for these papers, the BBS showed an improvement in all conditions regardless of the dance style. All p values in this table are significant or approaching significance, with the effect sizes ranging from .41 which would be a small to medium effect to 1.2 which is a very large effect. The greatest mean change was seen in Volpe (2013) which saw a 10 point improvement after a six month intervention of Irish dancing. When looking at the means however,

it is clear that participants were much more severely affected in balance than participants in the other studies. The post mean score for this paper (46.08) was approaching the pre scores of the other papers.

TUG

Table.4.3. Mean Scores on theTUGS with Effect sizes by study

Article	Date	N	Pre Mean	Pre (SD)	Post Mean	Post (SD)	Effect Size d	Sig.
Hackney et al.	2007	9	10.70	1.26	9.80	1.26	.71	.999
Hackney & Earhart (W/F)	2009a	17	10.90	31.34	10.80	4.95	.03	.999
Hackney & Earhart (T)	2009a	14	12.10	5.61	10.00	2.99	.37	.999
Hackney & Earhart	2009c	12	13.10	5.80	11.10	4.80	.34	.110
Hackney & Earhart (P)	2009d	19	13.60	9.00	13.20	9.00	.04	.999
Hackney & Earhart (N/P)	2009d	20	9.70	3.00	9.80	3.00	.03	.999
Marchant et al.	2010	11	9.60	1.99	9.10	1.79	.25	.055
Volpe et al.	2013	12	19.16	5.75	12.75	4.37	1.11	.001
McKee & Hackney	2013	24	10.10	3.10	10.30	3.20	.06	.477
Batson et al.	2014	7	12.38	5.96	10.00	.85	.56	.100
Hasimoto et al.	2015	19	11.6	2.4	9.7	2.1	.79	.006
Romenets et al.	2015	18	7.9	2.5	8.0	2.2	.04	.903

Effect sizes are shown in the format of Cohen's d. (W/F) indicates the Waltz/Foxtrot condition. (T) indicates the tango condition. (N/P) indicates the non partner condition. (P) indicates the Partner condition). For the TUG, a decrease on score indicates an improvement in walking ability.

Table.4.3. shows there are eight papers that use the TUG as an outcome measure after the dance intervention. The pre mean scores show quite a variation

between studies, with Marchant et al. (2010) starting on 9.6 seconds to complete the task and Volpe et al. (2013) starting on 19.16 seconds. For Romenets et al. (2015) participants' pre scores are lower than any of the other papers post means, so it unsurprising that no change was observed in this paper. The effect sizes tend to differ quite substantially with the smallest being .03 indicating a very small effect of the intervention, to the largest being 1.11 which shows a very large effect. The p values only give a slightly clearer picture as only Volpe et al. (2013) significantly improved over time and Marchant et al. approaching significance. Table.4.3. shows that for the TUG, the effects are less clear cut than for the BBS.

UPDRS III

Table 4.4 Mean Scores on the UPDRS II with Effect sizes by study

Article	Date	N	Pre Mean	Pre (SD)	Post Mean	Post (SD)	Effect Size d	Sig.
Hackney et al.	2007	9	30.60	4.11	22.60	4.11	1.95	.001
Hackney & Earhart	2009c	12	32.90	7.30	28.30	7.10	.63	.029
Hackney & Earhart (T)	2009a	14	27.60	7.48	26.00	9.35	.21	.344
Hackney & Earhart (W/F)	2009a	17	26.90	10.31	24.30	14.02	.25	.089
Marchant et al.	2010	11	26.90	11.61	21.50	6.63	.47	.016
Duncan & Earhart	2012	26	44.50	11.73	39.90	11.73	.39	.050
Volpe et al.	2013	12	24.58	3.87	17.42	3.85	1.85	.001
McKee & Hackney	2013	24	28.10	6.90	24.00	7.90	.59	.017

Effect sizes are shown in the format of Cohen's d. (W/F) indicates the Waltz/Foxtrot condition. (T) indicates the tango condition. For the UPDRS III, a decrease on score indicates an improvement in disease severity.

There were seven papers that used UPDRS III as an outcome measure. The pre means for these studies are quite similar except for Duncan & Earhart (2012), although this is to be expected as participants were tested off medication whereas participants in all other studies were taking their regular prescribed dosage.

Again there is a discrepancy between effect sizes, there are both small effects and very large effects after the dance interventions. However, the p values would indicate that six of the seven studies showed a significant improvement over time.

6MWT

Table.4.5. Mean Scores on the 6MWT with Effect sizes by study

Article	Date	N	Pre Mean	Pre (SD)	Post Mean	Post (SD)	Effect Size d	Sig.
Hackney & Earhart	2009c	12	347.80	77.20	383.70	122.10	.47	.170
Hackney & Earhart (W/F)	2009a	17	358.10	89.47	407.20	35.87	.55	.001
Hackney & Earhart (T)	2009a	14	364.20	94.66	423.60	35.92	.63	.001
Marchant et al.	2010	11	465.30	71.01	469.10	62.02	.05	.426
Duncan & Earhart	2012	26	398.46	109.93	398.46	111.56	.00	.999

Effect sizes are shown in the format of Cohen's d. Means are measured in metres travelled. (W/F) indicates the Waltz/Foxtrot condition. (T) indicates the tango condition. For the 6MWT, a decrease in score indicates an improvement in walking ability/endurance.

Table.4.5. shows that only four out of the ten papers used the 6MWT as an outcome measure. The pre mean score for Marchant et al. (2010) is substantially larger than the other papers, with the pre mean larger than any of the other papers post mean scores. It is unclear why this score is noticeably larger than

the other papers, especially after previous research has suggested no practice effects for this test (Canning, Ada, Johnson, McWhirter, 2006).

Effect size data range from zero with no change in mean score, to a medium effect of .63 for the tango group in Hackney & Earhart (2009a). In this case one paper found a significant improvement whereas the other three did not.

PDQ-39
For the purpose of this meta analysis only the total (PDQ SI) will be analysed.

Table. 4.6. Mean Scores on the PDQ-39 with Effect sizes by study

Article	Date	N	Pre Mean	Pre (SD)	Post Mean	Post (SD)	Effect Size d	Sig.
Hackney & Earhart (W/F)	2009a	17	23.32	5.40	21.64	5.40	.24	.999
Hackney & Earhart (T)	2009a	14	27.04	5.39	20.03	5.39	1.30	.001
Volpe et al.	2013	12	30.60	12.06	22.16	10.18	.70	.999
McKee & Hackney	2013	24	19.3	9.6	19.5	11.1	.02	.999
Romenets & Earhart	2015	18	25.8	15.1	24.5	12.9	.09	.562

Effect sizes are shown in the format of Cohen's d. (W/F) indicates the Waltz/Foxtrot condition. (T) indicates the tango condition. For the PDQ-39 SI, a decrease in score indicates an improvement in overall quality of life

Only four papers used quality of life as an outcome measure in the previous research. Only the tango condition of Hackney & Earhart (2009a) showed a significant improvement over time. However, when looking at the effect sizes, Volpe et al. (2013) had a large effect size. The p value was not reported in this study so are unable to know how close it was to $p=.05$. The paper reported $p>.05$ and therefore it has been included as .1 in this table as discussed previously.

Overall, the outcome measures appear to have some discrepancy between studies in terms of both effect sizes and significant changes over time. The meta analysis was be conducted in order to investigate this further.

4.3.4 Synthesis of results & Publication Bias

Results from each meta-analysis and associated fail safe N are described below.

BBS

Seven studies, containing dance interventions used the BBS as an outcome measure. A Significant homogenous SES was found in favour of dance intervention [SES(Random): .76, 95%CI .54 -.99;p<.001;I^2=0%]

Study name	Outcome	Hedges's g	Lower limit	Upper limit	p-Value
Marchant 2010	Contact Improvisation	0.941	0.268	1.613	0.006
Hackney 2009d	Combined	0.455	0.006	0.905	0.047
Hackney 2007	Tango	1.010	0.258	1.763	0.008
Hackney 2009a	Combined	0.995	0.403	1.586	0.001
Volpe 2013	Irish jig	0.588	0.011	1.164	0.046
Hackney 2009c	Tango	0.723	0.122	1.323	0.018
Hasimoto 2015	Dance	1.011	0.411	1.611	0.001
		0.764	0.542	0.985	0.000

Figure.4.2. Forrest plot for BBS

The Forrest plot shows that all the studies in the meta analysis has a significant improvement over time in favour of the dance intervention for BBS. The overall Hedges g was .725 suggesting a moderate to large effect size, this was statistically significant at *p*<.001. No confidence intervals intersect 0, indicating significant results for all papers included in the analysis.

Publication bias was assessed using the fail safe N. For the BBS, it was found that 81 non significant studies would need to be published in order to bring *p*>.05. Orwin's fail safe N also calculated that the number of non significant studies in order for a negligible effect size of .1 would be 47.

TUG

Ten studies, containing dance interventions used the TUG as an outcome measure. A significant homogenous SES was found in favour of dance intervention [SES(Random): .27, 95%CI .02- .52;p=.037; I^2=56%]

Study name	Outcome	Hedges's g	Lower limit	Upper limit	p-Value
Hackney 2009c	Tango	0.467	-0.092	1.025	0.101
Hackney 2009d	Combined	0.000	-0.426	0.426	1.000
Marchant 2010	Contact Improvisation	0.604	0.003	1.206	0.049
Volpe 2013	Irish Jig	1.191	0.481	1.902	0.001
McKee 2013	Tango	-0.143	-0.532	0.246	0.472
Hackney 2009a	Combined	0.000	-0.442	0.442	0.999
Hackney 2007	Tango	0.000	-0.590	0.590	0.999
Batson 2014	Contact Improvisation	0.325	-0.341	0.991	0.339
Hasimoto 2015	Dance	0.789	0.234	1.345	0.005
Romenets 2015	Tango	-0.028	-0.469	0.414	0.902
		0.266	0.017	0.515	0.037

Figure 4.3. Forrest plot for TUG

Figure 4.3 shows the data for the TUG outcome measure. The Forrest plot shows that there is more variation in this outcome measure in terms of statistically significant findings for the previous research. The overall effect size was .27, suggesting a small effect of dance on the TUG outcome measure. This however, was still statistically significant at p=.037.

Publication bias revealed that 15 non significant studies would need to published in order to bring p>.05. Orwin's fail safe N was also calculated to reveal that 10 studies would be required in order to have an effect size of .1.

UPDRS III

Four studies, containing dance interventions used the UPDRS III as an outcome measure. A Significant homogenous SES was found in favour of dance intervention [SES(Random): .72, 95%CI .419-1.028;p<.001; I^2=37%]

Study name	Outcome	Statistics for each study				Hedges's g and 95% CI
		Hedges's g	Lower limit	Upper limit	p-Value	
Volpe 2013	Irish Jig	1.191	0.481	1.902	0.001	
Hackney 2009c	Tango	0.674	0.083	1.265	0.026	
Marchant 2010	Contact Improvisation	0.805	0.164	1.446	0.014	
Hackney 2009a	Combined	0.333	-0.155	0.821	0.181	
Hackney 2007	Tango	1.518	0.601	2.434	0.001	
McKee 2013	Tango	0.508	0.095	0.921	0.016	
		0.724	0.419	1.028	0.000	

Figure 4.4. Forrest plot for UPDRS III

Figure 4.4. shows that for the majority of the papers, the effect sizes are quite large and do not intersect zero. The overall Hedge's g effect size for UPDRS III is .72 which suggests a moderate to large effect size. This is not surprising as only one paper (Hackney & Earhart, 2009a) did not show a statistically significant result.

Publication bias was assessed using the fail safe N. It was found that for the UPDRS III, 53 non significant studies would need to be published in order to bring $p > .05$. Orwin's fail safe N also calculated that the number of non significant studies required for a Hedge's g of .1 would be 35.

6MWT

Four studies, containing dance interventions used the 6MWT as an outcome measure. A non significant heterogeneous SES was found in favour of no change [SES(Random): .37, 95%CI -.045-.783; p=.081; I^2=62%]

Study name	Outcome	Hedges's g	Lower limit	Upper limit	p-Value
Duncan 2012	Tango	0.000	-0.372	0.373	0.999
Hackney 2009c	Tango	0.394	-0.155	0.944	0.160
Marchant 2010	Contact Improvisation	0.231	-0.323	0.785	0.414
Hackney 2009a	Combined	0.995	0.403	1.586	0.001
		0.369	-0.045	0.783	0.081
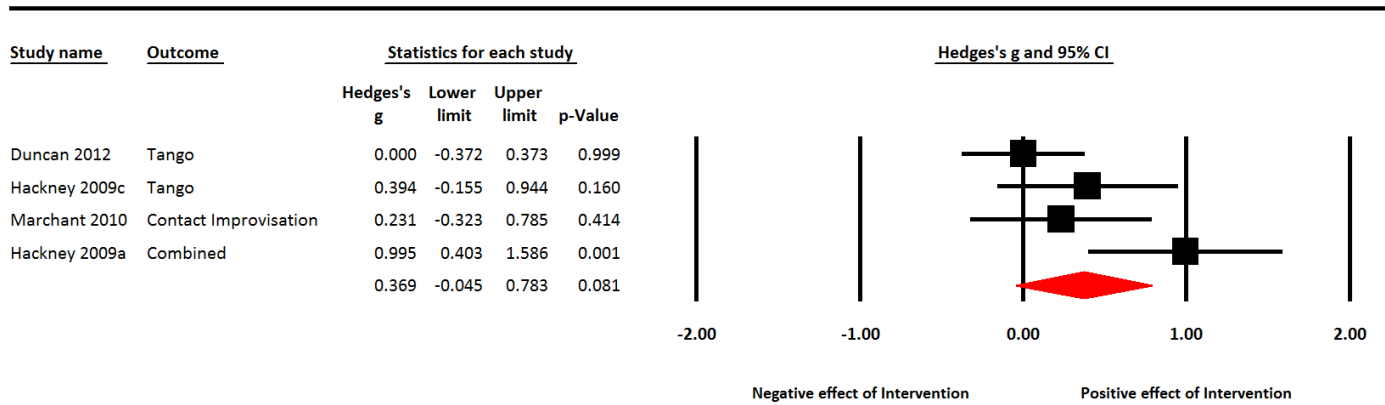
Figure 4.5. Forrest plot for 6MWT

The Forrest plot shows that only one paper had a significant improvement out of the four previous papers. The p value shows a trend towards a significant change over time for participants completing the dance intervention (p=.08). As there are only four studies in which this outcome measure is used, it is unclear whether additional research would change this statistic either way.

No publication bias was calculated for this outcome measure as the meta-analysis was non significant.

PDQ-39

Four studies, containing dance interventions used the PDQ-39 as an outcome measure. A significant homogenous SES was found in favour of dance intervention [SES(Random): .13, 95%CI -.10 -.36;p=.286; I^2=0%]
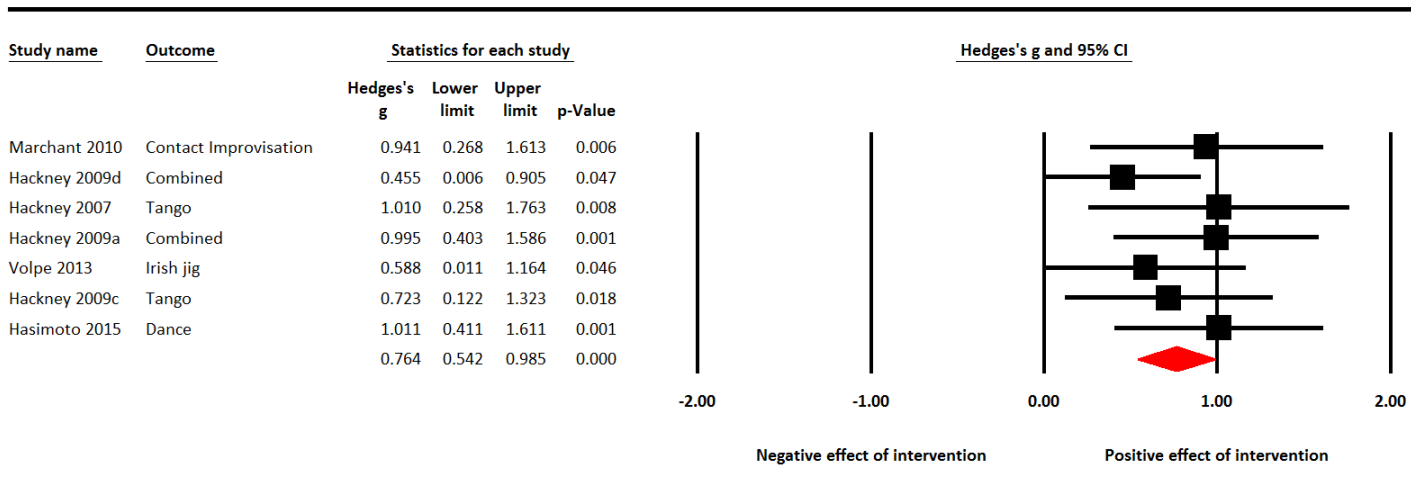

Study name	Outcome	Hedges's g	Lower limit	Upper limit	p-Value
Hackney 2009a	Combined	0.531	-0.018	1.080	0.058
Volpe 2013	Irish Jig	0.000	-0.526	0.527	0.999
McKee 2013	Tango	0.000	-0.387	0.387	0.999
Romenets 2015	Tango	0.133	-0.310	0.577	0.556
		0.131	-0.101	0.362	0.268
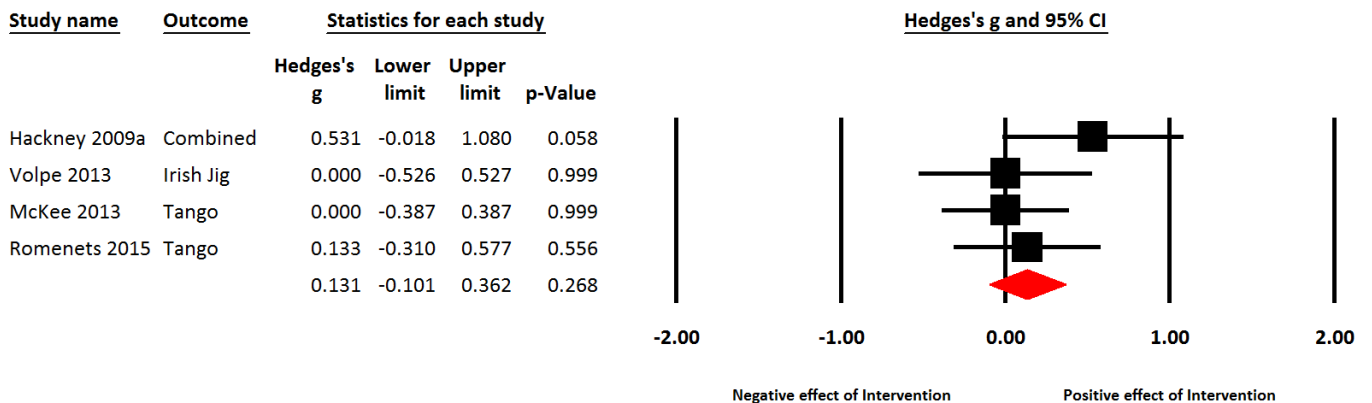
Figure 4.6. Meta analysis and Forrest plot for PDQ-39

The overall Hedge's g effect size for the three studies is .13. This suggests very little change over time for overall quality of life from the published research. There was a non significant p value of .27 suggesting that dance interventions do not have a significant impact on quality of life.

No significant changes were seen for the PDQ-39 and therefore publication analysis was not computed.

4.4 Discussion

The meta analyses showed that there was a significant effect of the dance intervention for three of the five outcome measures, BBS, UPDRS III and TUG. For the BBS the overall Hedge's g effect size was .76 indicating a large effect. A large effect was also seen for the UPDRS III, with an effect size of .72. For the TUG the overall effect size was .27 indicating a small effect size. Both the 6MWT and PDQ-39 did not show a significant change over time for the dance interventions. Interestingly, the 6MWT has an effect size of .37 which was larger than the significant TUG. As this measure showed a small to medium effect size, and a trend towards significance, the relationship between dance interventions and this outcome measure is not clear cut, and additional research should be conducted using this outcome measure. The PDQ-39 SI showed no significant changes over time for the studies and a small effect size of .14, suggesting that the dance interventions had no effect on overall quality of life. These two outcome measures did however include fewer papers than the significant BBS, UPDRS III and TUG. This may suggest additional power to investigate these outcome measures further, before concluding that dance has no effect on walking ability and overall quality of life.

Publication bias analysis showed that for both the UPDRS III and BBS would require a number of non significant studies to be published for a meta analysis to conclude that there was no effect of dance on BBS scores. This shows that the BBS and UPDRS III are strongly affected by the dance interventions that have been run in the past. It would be concluded that dance interventions have an effect on both balance and disease symptoms. For the TUG, publication bias

analysis showed that 15 non significant papers would be required for a non significant meta-analysis to be conducted. Although this a moderate number of papers, coupled with the low effect size dance appears to have a smaller effect on this outcome measure. Taking both TUG and 6MWT into account it is not clear how much of an effect dance has on walking ability. Both studies showed some improvement, however, it does appear to be much smaller than the BBS and UPDRS III. For the PDQ-SI, the meta analysis showed a non significant change over time and with a small effect size of .143, suggesting there is no effect of dance interventions on overall quality of life.

The current meta-analysis findings differ from two of the three previous meta-analyses.   The current meta-analysis focuses on the changes from pre to post on a number of dance interventions. Previous literature (Shanahan et al. , 2015, Sharpe & Hewitt, 2014) split the meta-analyses, and compared other treatment groups within the analysis. This led to many studies being excluded from the analysis, and low sample sizes. The current meta-analysis is most comparable to Lötzke et al. (2015). Both Lötzke et al. (2015) and the current meta-analysis both found that dance can improve the BBS, UPDRS III and TUG. Lötzke et al. (2015) found these significant changes when comparing the previous Argentine tango research. The current study used a number for different dance styles in the analysis and came to the same conclusions. This would suggest that all dance styles may be beneficial on these outcome measures. With that said, the current meta-analysis did include a large number of studies investigating the effect of tango. Without more studies specifically investigating other dance forms on the symptoms of PD, it is difficult to know whether there are any real differences between different forms of dance and whether they can be beneficial on different aspect of physical and psychological measures. These findings show that different forms of dance, not only tango can prove beneficial for those with PD. All studies included in the meta-analysis included social, movement and music aspects. This meta-analysis suggests that dance is beneficial for these three outcome measures, but it is unknown whether dance is unique or whether other activities that include these three aspects (such as exercise to music in a group setting) could also show these benefits.

The current meta-analysis has compared pre and post scores from the dance treatment group, regardless of the other intervention groups. This has ensured a larger sample size to investigate the role of dance on PD more comprehensively. In future, comparisons between different interventions would be beneficial, but only if the number of research studies increase to make this a viable option.

With that said, the findings of the current study are in line with those of Shanahan et al. (2015). Both meta-analyses found improvements in BBS, TUG and UPDRS III following dance. Since that meta-analysis was published a number of studies have become available, the current meta-analysis has shown that Shanahan et al (2015) findings do not change the overall view that these outcome measures improve after dance. From the analysis, it is clear that many non-significant papers would be required to change the result for the BBS specifically and therefore this finding appears reliable, and we can conclude that dance sessions do in fact appear to improve balance. Although both the UPDRS III and TUG also show overall significant results, there are more ambiguous, with some papers finding improvements and others not. This could be for a number of reasons, such as length of intervention/ type of dance/ intensity etc. These results are significant and should be treated as such, however less papers would be required to produce a non-significant result. Without knowing how many non significant results have not been published, these outcome measures do require more research to get a clearer picture of the changes that can be observed following different forms of dance.

There was substantial variation in some of the measures, in terms of effect sizes. This could be due to the dance study or length of intervention. This meta-analysis included studies that differed in dance study (waltz/foxtrot, Irish dancing, contact improvisation and tango), which may have differing effects on the symptoms of PD. The length of intervention also differs within this meta-analysis, with the shortest intervention being two weeks and longest at three months. Again the duration (and frequency per week of intervention) may have an effect on the overall outcome. From looking at the pattern of the results from

the previous research it is difficult to say whether longer, less frequent studies have different outcomes compared with shorter more frequent interventions. To date only Hackney & Earhart (2009b) and Marchant et al. (2010) have investigated short intensive durations (two weeks), whereas additional studies have tended to range from 10-12 weeks. Tango has been investigated by far the most prolifically (Hackney, Earhart, Kantrovic & Levin, 2007; Hackney, Kantrovic & Earhart, 2007; Hackney & Earhart, 2009abd; Romenets et al. , 2015). There is no evidence to suggest that this form of dance is any more beneficial than the others investigated in previous research (contact improvisation, Irish dancing, waltz/foxtrot and a mix of dance styles) This is despite Hackney & Earhart (2009a) concluding that tango is most effective. A meta-analysis taking all these factors into account is not possible at this stage due to the lack of relevant papers. As this is an emerging area of research, meta-analyses in the future may be able to explore these factors in more detail.

The papers included in the current meta-analysis differ widely in terms of dance style and methodology. The previous research has tended to include small sample sizes, and few comparison groups. There have been limited RCTs and therefore the methodological quality has suffered (this can be seen with the PEDro scores listed previously). It is difficult to compare these heterogeneous studies, but the meta-analysis has given an indication of the type of effects that can be seen following dance sessions. The form and length of interventions differ across the studies, so no explanations regarding most effective treatment can be established from this meta-analysis. Additional research in this area is required to answer these questions of the most effective interventions for people with PD.

There are a number of questions that still need answering within this research further than the physical effects of the interventions. A number of studies have begun to focus on psychological and cognitive improvements after dance, however there were too few to include in this meta analysis for example Lewis, Annett, Davenport, Hall & Lovatt (2014) that investigated the effect of dance on mood both over a short term period (before and after a dance class) and longer

term (ten weeks). Mckee et al. (2013) investigated spatial cognition over a ten week period and found a significant improvement in executive function. The questions these papers pose are very important and further research is required in this area to investigate these in more detail. This meta- analysis was confined to these five outcome measures as they were the most common within the literature. Some of these papers above have very noteworthy findings and further research should be completed.

The current meta-analysis showed significant changes in BBS, UPDRS III and TUG, and no change in scores of 6MWT or PDQ-39. Both the TUG and 6MWT are walking tasks, so it is interesting that they show differing results in the meta-analysis. The format of these tasks are very different, with the TUG typically lasting between 8 and 12 seconds in the elderly. The TUG is concerned with a number of aspects of movement, such as co-ordination, balance and gait. It has been found to correlate well with measures of balance and gait (Podsiadlo & Richardson, 1991). The 6MWT is a measure of walking endurance. This suggests that these tasks, although both walking tasks are measuring different aspects of physical ability, co-ordination vs. endurance.

The meta-analysis has already shown that dance can improve balance in those with PD; it may be that balance and co-ordination has improved within this task. This allows faster and more stable turning and in turn decreasing the time it takes to complete the task. The 6MWT measures distance travelled only. It may be that the participants gait, posture and balance may well be improved but the distance participants can walk in six minutes does not measure this. Participants may be standing straighter and more stable throughout the task, but unable to walk any further than their pre assessment.

It is well noted that those with PD have higher levels of fatigue than elderly counterparts (Garber & Friedman, 2003), with up to 30% of those with PD rating this as their most disabling symptom (Krupp & Pollina, 1996). It may be that the 6MWT is too long for participants to walk unassisted causing fatigue. This was investigated in post stroke patients (Liu, Drutz, Kumar, McVicar, Weinberger,

Brooks, & Salbach, 2008). Participants completed the 6MWT twice with a 30minute break between. The study aimed to investigate whether there were practice or fatigue effects from completing this task. The study found no significant differences between distances travelled between first and second trials of this task. This would suggest that even when participants complete this task twice in a short space of time, there were no fatigue effects. This however depends on how long it takes participants to recover from fatigue, it may well be that participants were able to recover from this fatigue in 30 minutes. Earhart & Falvo (2008) also described that no participants with PD completing the 6MWT in their study had to have a rest during the task. This would suggest that participants are able to cope with this task and fatigue would not be an issue in this task.

Overall, the quality of papers need to improve across the board. Proper reporting of means, standard deviations and p values for all outcome measures needs to be improved. A number of the papers discussed in this meta-analysis did not include all the information required to compute effect sizes and authors needed to be contacted to gain this information. This is basic information that should be included in all papers. For a number of p values included in the analysis, estimates were computed as they were not discussed in the text. For a number of outcome measures, $p<.05$ or $p>.05$ was simply reported.

The papers described in this analysis tended to have a three month maximum intervention with pre and post assessments (with the exception of Duncan & Earhart, 2012). Longer term studies are required to investigate the role of dance on the symptoms of PD further.

The previous research into dance for PD has focused on comparing different dance styles and durations etc. The research needs to investigate a longer term intervention with larger sample sizes, integrating a number of different activity groups. The research has begun to investigate some of these key factors, such as the role of social groups (McKee & Hackney, 2012), exercise (Hackney & Earhart,

2007a;2007b) and multiple test points duration (Duncan & Earhart, 2012) but this needs to be explored further to understand this topic more thoroughly.

One topic that all the research has failed to address is the mechanisms by which dancing may have an effect on the symptoms. Suggestions have been made within some discussions of the previous research (a full write up of these can be seen in Chapter 10), but this needs to be investigated further. Are there particular aspects of the dance that have been shown to be more beneficial, whether it is improvised dance or the cognitive load that put on to participants whilst learning steps? Is the role of music as important as they type of dancing completed? These questions warrant further exploration and are discussed in detail in the discussion chapter.

There are a number of issues with almost all the research that has been published to date, whether it be methodological issues or statistical problems. There has been a lack of papers comparing different experimental groups as well as controls. This would help to effectively compare whether dance is more beneficial than exercise, or other social activities. A further exploration into the intervention duration and frequency is also required to explore who effective these interventions can be. Key questions that these papers do not answer include:

- How long do the effects of the intervention last? Is there a tail off after a certain length of time?
- Are there short term effects of the dance studies? Do participants show immediate gains after completing a dance session and how long do they last for?
- Are there differences in the effects of different dance styles? Differences in cognitive load such as the comparison of taught dances VS improvised dances. Are there any effects in cognitive domains?
- What are the mechanisms in which dance is helping the symptoms of PD?

There are some key points that need addressing to make this research more rigorous and help us to answer the question of whether dance does in fact improve the symptoms of PD.

Chapter 5: Social Dances

5.1. Previous literature

Research has suggested that short-term exercise can increase positive mood and decrease negative mood (Hansen, Stevens & Coast, 2001; Kennedy & Newton, 1997) in the general population. Improvements in mood following dance have also been observed in professional dancers. Lane, Hewson, Redding and Whyte (2003) found significant improvements in the dimension vigor, as measured by the Brunel University Mood Scale (BRUMS) following a modern dance class. Interestingly these results differed between different forms of modern dance, with those completing Limon dance showing improvements and those completing Graham dance did not. These two forms of modern dance differ in their styling. Graham technique focuses on the contraction and release of the body especially the movement of the spine, this differs to the Limon technique that focused on breathing and energy with bouncing and swinging motions (ascendance.org.uk). This study shows changes in mood can be observed after just one dance class. Participants were also completing a number of dance lessons per day at the dance school and therefore findings may not generalise to those completing dance on a less frequent/intense basis. As participants were training at a dance school, it is to be expected that this activity would improve their mood. Participants are clearly passionate enough about dance to attend this dance school, and therefore the general public may not have such a strong reaction.

Kim and Kim (2007) explored the effect of different forms of exercise on mood in high school and undergraduate students. Participants were assigned to aerobic exercise, hip hop dance, ice skating or body conditioning group. Participants completed one hour of activity with a mood questionnaire administered pre and post activity. Both aerobic exercise and hip hop dancing groups were found to have significantly improved wellbeing and decreased psychological distress. No changes were observed for the ice skating and body conditioning groups. This study shows that mood changes can be observed immediately following different

forms of physical activity. Although all groups included physical exertion, there were different patterns of results, suggesting that activities had different psychological effects on participants. These findings show that just because an activity includes physical movement, does not mean it will have a benefit for mood levels, and that different activities can have differing effects of mood.

There has however, been research to suggest that no changes in mood were observed in the elderly following dance (Alpert et al, 2009; Eyigor, Karapolat, Durmaz, Ibisoglu & Cakir, 2009). Eyigor et al. (2009) conducted research using Turkish Folklore dance on a group of elderly women, to determine whether this form of intervention would have an effect on physical and psychological wellbeing of the participants. Significant improvements were observed in balance and quality of life, although no changes were seen in feelings of depression.   Levels of depression also showed no change following jazz dance classes for the elderly (Alpert et al, 2009). To date, no research has investigated the role of mood in those with PD following dance sessions, either immediately following a session or over a longer term. Research has suggested that improvements in mood were greater in those with depression compared to a non-depressed group following a dance exercise session (Lane & Lovejoy, 2001). Those with PD have been shown to have a higher instance of depression and anxiety than elderly controls (Gotham, Brown & Marsden, 1986; Cummings, 1992: Richard, Schiffer & Kurlan, 1996). This may indicate that those with PD may differ in changes in mood compared to controls. This will be measured in the current study, comparing changes in mood in those with PD with elderly controls. The previous studies have measured mood changes both immediately after dance and up to a week after the intervention concludes. Both these formats will be explored in relation to dance sessions with those with PD.

Heiberger et al. (2011) measured the short cycle effects of balance and mobility after one dance class. Participants were given a quality of life questionnaire before and after a one-hour dance class and found significant improvements following dance. This research suggested that immediate gains can be seen on mobility, as shown by the improvement in the UPDRS III. The current study will

also investigate short term changes in mood as well as longer term mood fluctuations. A mood scale will be administered to investigate this in more detail.

A number of the participants in study one were very near the top end of the BBS, showing ceiling effects, in addition, the Mini BESTest (Franchignoni, Horak, Godi, Nardone & Giordano, 2010) was included as it is more sensitive for those with milder balance issues. The MiniBESTest has been shown to be more sensitive than the BBS (King, Priest, Salarian, Pierce and Horak, 2011) and more effective at predicting UPDRS scores. The Dual TUG was also included as an outcome measure, as well as the TUG. This is assessed within the MiniBEST but can be analysed in its own right. As previous literature has shown TUG scores close to normal for this population, adding another task to the TUG (counting back in three's from 100) will make the task more difficult and therefore more likely to highlight the effect of the disease on more complex tasks.

In order to investigate whether changes in outcome measures are exclusive to those with PD, a non PD group have been included in the study, previous literature has looked at those with PD and not on elderly matched controls. The current study aims to investigate whether there are differences in the pattern of improvements between the PD and non-PD group as well as pre and post scores.

5.2 Method
5.2.1 Participants
Participants were 38 elderly individuals, 22 with PD and 16 without PD. Twenty six of the 38 participants had some dance experience in the past. However, only one participant from the PD group and four from the non-PD group were actively dancing before the intervention.

All participants were assessed as having mild to moderate PD (Hoehn & Yahr score of I-III). One Participant from the non-PD group was excluded for scoring below the cognitive cut off point in the MMSE (Folstein et al. 1975). Six participants did not complete both assessment sessions and subsequently, only data from these 32 participants were analysed. Throughout the study, one non-

PD participant dropped out due to work commitments and another for medical reasons. One participant was absent from post testing due to illness. However, this participant did fill in the participant post pack, but did not complete the physical measures. Four participants (two with PD and their respective partners) were unable to attend the post testing assessment session due to holidays. Therefore, this study had an attrition rate of 16%.
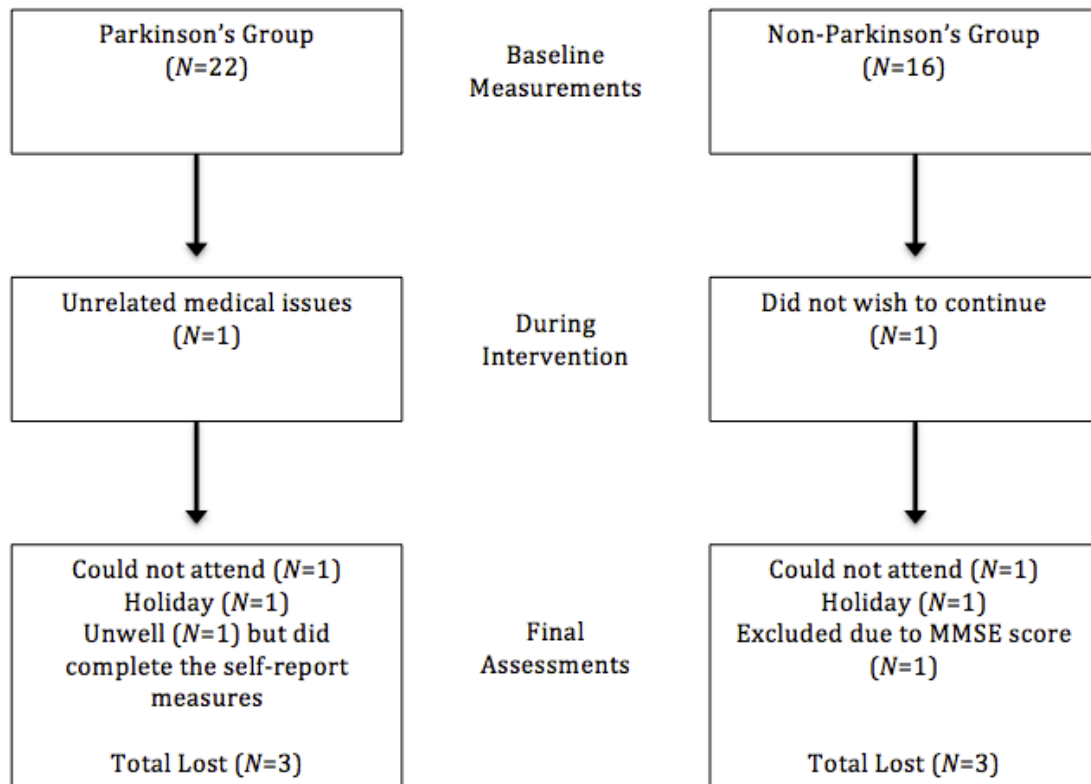
Figure 5.1. Flow chart to show reasons and number of drop outs in study 2

Participants were required to complete over 70% of the dance sessions in order for their data to be included in analysis. All participants completed more than this minimum requirement.

In terms of safety, the participants were given a self report questionnaire to establish fallers in the group. None of the non PD group classified themselves as fallers, however four participants with PD felt they were fallers. These participants were evenly distributed in the two separate classes, with two of the

93

fallers in each class. This was to ensure enough volunteers were on hand for safety and that both classes could progress as the same speed.

5.2.2 Measures

Cognitive tests were assessed before and after the intervention. Data for divergent thinking tasks were scored by two raters and inter-rater reliability was calculated for each of the measures. This included the research and another member of the team. For all subsections the inter-rater reliability between raters was above .7 for each apart from originality and therefore this dimension will not be included within the analysis. To get a more accurate score from each of the dimensions of the AUT and ATTA, the average mean scores between the two raters were used in the analysis.

Data analysis of both the POMS and the BRUMS has been completed using raw scores. Previous research (Lane, Hewson, Redding & Whyte, 2003) has typically converted these scores into t scores using normative data (Terry & Lane, 2000). However, this normative data is for sports students and would not be appropriate for analysis of the elderly population. There is no normative data available for an elderly population and particularly those with PD.

The above measures were assessed pre and post the intervention. A mood scale was also taken before and after the 9th dance class, to identify whether there are short term benefits for participants. Participants were given the Brunel University Mood scale, BRUMS (Terry, 1999, 2003) which is a modified, 24 item, version of the POMS (McNair, 1971) and is comprised of the same subscales, Tension-Anxiety, Vigor-Activity, Depression-Dejection, Fatigue-Inertia, Anger-Hostility and Confusion-Bewilderment, but with a total score for each subscale of 16. The total Mood Disturbance (TMD) is measured between -16 and 80, a lower score indicating a more positive mood.

Participants were asked to keep diaries of their thoughts and feelings towards the study throughout and completed a 20 minute exit interview following post assessment.

5.2.3 Design

The current study has a 2X2 within subjects design. With Independent variables of condition, with two levels (PD and Non PD), and time with two levels (pre and post assessment). Dependent Variables (DV's) were BBS, UPDRS I, II, III & IV, TUG, Dual TUG, The mini BESTest, AUT, ATTA, MRT, LDT, FES, PDQ-39, POMS and BRUMS. An explanation of each of these tests can be seen in chapter 3. Data from 12 participants with PD and 11 Non PD was obtained pre and post the dance class. Pre mood scales that were completed after the group began dancing were removed (late comers completing the scales during the break).

5.2.4 Hypotheses

- Dance will improve balance in those with PD
- There will be no effect of dance on balance in non PD participants
- Dance will improve mood in those with PD
- Dance will improve quality of life in those with PD

5.2.5 Procedures

Before the initial assessment, participants were sent information packs to complete and return on the assessment day. Participants then attended an assessment session prior to starting the dance intervention programme. During this assessment day, participants were required to complete a number of functional and cognitive tests (outlined above) as a baseline measure. Additionally, participants were given a diary to record all their thoughts and feelings throughout the intervention. Participants were assessed 'ON' medication and self selected the time of day to be assessed, this time was used again during the post testing assessments.

Participants were also issued with an unstructured diary during the first assessment session. They were also advised that there would be an exit interview following the post assessment day (interview schedule can be seen in D). It was indicated that participants should use this over the course of the study to record any comments they had toward the research. No specific instructions

were given regarding frequency or content of the diaries.

The first dance class was completed approximately 4 days after the pre assessments. Participants were split into 2 classes to complete the dances, participants self selected which session they would prefer to attend as a number of participants were travelling quite a long distance to attend. Regardless of this, the groups had an equal number of participants with and without PD. These classes were immediately after each other on a Monday evening. This was in order to maintain an acceptable participant to teacher ratio, with enough helpers present to ensure safety. The same dance teacher taught both the dance classes and ensured the same amount/level of content was delivered to both groups. The dance teacher had experience teaching dance to an elderly population, but no experience with PD. Each of the dance classes was approximately 50 minutes long with a 5-minute break.   Below is an outline of the dances learnt each week.

Weeks 1 & 2: Bollywood

Weeks 3 & 4: Tango

Weeks 5 & 6: Cheerleading

Weeks 7 & 8: English Music Hall

Week 9: Party Dancing (Guest Dance Teacher)

Week 10: Recap of the previous dances

To investigate the short term mood effects of the dance class, participants were given a mood questionnaire before and after the 9th dance class. Participants were required to complete the BRUMS (Terry, 1999, 2003) before and after the session to assess changes in mood scores.

During the class on Week 10, participants were given another set of Participant Packs to fill in before the post assessment sessions. The post assessment session then took place in the week after the 10th dance session. The assessments for this session were the same as the pre assessment session.

Participants were also invited to a semi-structured interview following the final assessments, participants were assured that they could discuss any aspects of

the dance sessions/ research with the interviewer and that all responses would be anonymous. Participants completed the interview in a quiet room, in which audio recordings were taken for transcription purposes.

Areas discussed with participants included: thoughts on the dance intervention overall with specific likes/dislikes of the different dances; thoughts on the teaching, rooms and practicality of attending and thoughts on practice undertaken outside of the classes.

5.2.6 Statistical analysis

Repeated measures ANOVA was used during statistical analysis, due to the pre and post nature of the study. Full details of assumptions for repeated measures ANOVA can be seen in appendix C, any violations will be discussed in the text.

During data input, the data were screened for outliers. From the Boxplots, outliers and extreme cases were identified and investigated. For a number of these cases, these were true values that were above or below the mean score significantly. When using a group that differs in symptoms such as those with PD, this is unsurprising. Extreme cases, if relevant, were excluded.

For both the diaries and interviews, analysis was conducted using a qualitative thematic content-interpretative approach (Braun & Clarke, 2006). Data were transcribed by a researcher from audio recordings and analysed by two researchers.

Out of 32 participants, 18 diaries were returned at post testing, these included 11 from those with PD. Twenty-three exit interviews were conducted at post testing, 18 of these were those with PD/ their partners. Five interviews were run with controls non related to those with PD.

5.2.7 Ethics

Ethical approval was obtained from the School of Psychology Ethics committee at the University of Hertfordshire. Registration Protocol Number: PSY/09/11/PL/LA/HSD.

5.3 Results

Participants were aged between 50 and 80, the groups did not significantly differ on age (PD Mean age=65, SD=9.41; Non PD Mean age=66, SD=8.65). There were an equal number of males and females in both groups (PD male =12, PD female =10, non PD male =7, non PD female =9). Eight out of 16 participants in the non-PD group were partners of those in the Parkinson group.

Both the Non PD and PD group completed the POMS questionnaire before the Pre and Post assessment sessions. Their data broken down into six subcategories, mean scores are shown in Table 5.1.

Table.5.1 Mean (SD) POMS scores for PD and Non PD participants

	PD		Non PD	
	Pre	Post	Pre	Post
Tension- Anxiety	9.86 (6.58)	7.67 (5.16)	8.79 (4.89)	6.23 (5.0)
Depression- Dejection	7.24 (9.03)	6.89 (8.12)	9.0 (9.73)	6.17 (8.18)
Anger-Hostility	5.86 (5.6)	5.16 (5)	8.93 (8.91)	3.25 (3.5)
Vigour-Activity	16.36(7.28)	16.78 (7.4)	16.33 (6.37)	19.18 (6.98)
Fatigue- Inertia	9.24 (7.12)	8.11 (5.64)	8.0 (4.96)	7.17 (5.32)
Confusion- Bewilderment	7.14 (4.82)	6.06 (4.49)	4.71 (4.34)	3.36 (4.20)
Total Mood Disturbance	22 (33.88)	17 (30.58)	22.86 (34.95)	9.1 (29.08)

These data show a trend for all participants to show an improvement in each subsection of the POMS (McNair, 1971) from pre to post testing.

Table 5.2 Mean (SD) Geriatric Norms for Males and Females on the POMS questionnaire (Nyenhuis et al.,1999)

	Tension-Anxiety	Depression-Dejection	Anger-Hostility	Vigour-Activity	Fatigue-Intertia	Confusion-Bewilderment
Males	4.6 (3.7)	4.3 (5.4)	3.9 (4.5)	22.3 (5.7)	5.0 (4.9)	3.9 (2.9)
Females	6.9 (5.9)	6.9 (7.5)	4.7 (4.9)	20.6 (6.2)	6.9 (5.6)	4.9 (3.8)
Total	5.9 (5.2)	5.8 (6.7)	4.4 (4.7)	21.3 (6)	6.1 (5.4)	4.5 (3.5)

On comparison of table 5.1 and 5.2, it is clear that participants in the current study, both with PD and non PD have a less positive mood scores than the geriatric norms. This is especially interesting for the non PD group in the current study as it would be expected that their mood scores would be similar to generic norms than the PD group. However, the non PD group included seven participants that were partners of those in the PD group, this may have affected the overall scores of the non PD group. However, an independent samples t test revealed no significant differences between participants in the non PD group, that were partners or non-partners of those with PD.

Data were subjected to a series of 2 way mixed ANOVAs. Factor 1: Group (PD vs. Non PD), Factor 2: Long Cycle Time (LC Time) (week 1 vs. week 13). Assumptions were tested before ANOVA's were run.

<u>Tension-Anxiety</u>

There was no significant main effect of group ($p > .05$), there was a significant main effect of LC Time, $F(1, 27)$, 5.43, $p = .028$, partial eta^2 = .167. The interaction was not significant ($p > .05$). Tension-anxiety scores were lower in week 13 than in week 1 for both groups.

<u>Depression-Dejection</u>

No significant effects ($p > .05$ in all cases).

Anger-Hostility

There was no significant main effect of group ($p > .05$), there was a significant main effect of LC Time, F(1, 28), 9.07, $p = .005$, partial eta$^2 = .245$. There was a significant interaction between group and LC Time, F(1,28), 6.91, $p = .014$, partial eta$^2 = .198$ Paired samples t tests showed a significant reduction in anger-hostility scores in the non PD group t(11) 3.36, $p = .006$, but not in the PD group ($p > .05$).

Vigour-Activity

There was no significant main effect of group ($p > .05$), there was a significant main effect of LC Time, F(1, 28), 5.54, $p = .026$, partial eta$^2 = .165$. The interaction was not significant ($p > .05$). Vigour-activity scores were higher in week 13 than in week 1 for both groups.

Fatigue-Inertia

There was no significant main effect of group ($p > .05$), there was a significant main effect of LC Time, F(1, 27)4.44, $p = .044$, partial eta$^2 = .141$. The interaction was not significant ($p > .05$). Fatigue-Inertia scores were lower in week 13 than in week 1 for both groups.

Confusion-Bewilderment

No significant effects ($p > .05$ in all cases).

Total Mood Disturbance Scores (TMD)

There was no significant main effect of group ($p > .05$), there was a significant main effect of LC Time, F(1, 26)=5.75, $p = .024$, partial eta$^2 = .181$. The interaction was not significant ($p > .05$). TMD scores were lower in week 13 than in week 1 for both groups.

It is worth noting that with many of the results discussed above, the scores for each subscales are rather low. Significant changes have tended to occur when the mean pre scores are higher and then improve at post testing. As many of the

scores are already rather low, floor effects may have prevented an improvement in some of the subscales.

Short Cycle Mood

BRUMS scores, for each subscale, are shown in table 5.3 as a function of group and Short Cycle Time (SC).

Table 5.3. Mean (SD) BRUMS scores for PD and Non PD

Group	PD (*N*= 15)		Non PD (*N*= 11)	
Short Cycle Time	Before class	After class	Before class	After class
Tension - Anxiety	1.27 (1.71)	.59 (1.28)	1 (1.81)	.36 (1.21)
Depression - Dejection	.60 (1.30)	2.36 (.66)	1.17 (2.48)	.27 (.90)
Anger - Hostility	.077 (.28)	.063 (.25)	.50 (1.24)	0 (0)
Vigour - Activity	9.15 (3.89)	10 (4.11)	10.36 (3.85)	13.4 (1.65)
Fatigue - Inertia	3.92 (3.55)	3.65 (3.84)	2.75 (3.33)	.91 (1.45)
Confusion - Bewilderment	.83 (2.0)	2.06 (3.55)	.58 (1)	0 (0)
Total Mood Disturbance	-1.45 (8.71)	-3.67 (11.02)	-3.5 (9.75)	-11 (5.16)

Tension-Anxiety

There was no significant main effect of group (*p*> .05), there was a significant main effect of SC time, $F(1, 24)$ 4.47, *p*=.045, partial eta^2= .157. The interaction was not significant (*p*> .05). Tension-anxiety scores were lower after class than before class for both groups.

Depression-Dejection

No significant effects (*p*> .05 in all cases).

Anger - Hostility

No significant effects (*p*> .05 in all cases).

Vigour-Activity

There was no significant main effect of group (*p*> .05), there was a significant main effect of SC Time, $F(1, 21)$ 5.72, *p*= .026, partial eta^2= .212 . The interaction

was not significant ($p > .05$). Vigour-Activity scores were higher after class than before class for both groups.

Fatigue – Inertia
No significant effects ($p > .05$ in all cases).

Confusion - Bewilderment
No significant effects ($p > .05$ in all cases).

Total Mood Disturbance Scores (TMD)
There was no significant main effect of group ($p > .05$), there was a significant main effect of SC Time, $F(1, 19)$ 4.26, $p=.033$, partial eta$^2 = .217$. The interaction was not significant ($p > .05$). TMD scores were lower after the class than before class for both groups.

PDQ-39 (Peto et al., 1995)
For each subscale within the PDQ-39, the raw score has been computed to generate a score between 0 and 100. A lower score indicates a better quality of life on each subscale. The means and standard deviations can be seen in table 5.4.

Table 5.4 Means (SD) table for PDQ-39

	Week 1	Week 13
PDQ- 39:		
SI (*N*=13)	24.15	24.69 (16.41)
Mobility (*N*=16)	22.88 (20.77)	19.38 (14.87)
ADL (*N*=17)	20.30 (19.90)	17.65 (11.56)
Emotional Wellbeing (*N*=16)	17.42 (11.56)	13.45 (15.04)
Stigma (*N*=17)	14.68 (22.32)	14.34 (18.72)
Social Support (*N*=11)	4.13 (8.08)	3.33 (7.03)
Cognition (*N*=17)	19.94 (13.45)	21.69 (16.7)
Communication (*N*=17)	22.98 (18.78)	13.60 (11.31)*
Bodily Discomfort (*N*=16)	29.19 (21.68)	24.48 (18.38)

Values are Means (SD).

Abbreviations: PDQ 39 39 SI, PDQ 39 39 Summary Index. PDQ 39 ADL, PDQ 39 39 Activities of Daily Living.

Participant numbers for each subsection differ due to missing data. Although, data is missing in one subsection, the other subscales can still be calculated. The PDQ 39 SI requires no missing data in order to calculate the total score. Participants were not required to complete the social support questions if they did not have a spouse.

Paired samples t tests were conducted to assess significant changes between pre and post assessments. All PDQ-39 subscales did not significantly change over time *p*>.05, with the exception of Communication. Participants significantly improved from *p*re to post assessments t(16)3.157, *p*=.006, r^2=.61.

Table 5.5. Mean scores for Physical tests

	PD		Non PD	
	Pre	Post	Pre	Post
BBS	55.27 (1.03)	54.13 (2.10) †	56 (.00)	56 (.00)
TUG	9.60 (2.07)	9.00 (1.65) †	7.56 (1.52)	7.85 (1.83)
Dual TUG	12.89 (3.79)	11.01 (5.12)*	9.62(2.01)	11.29 (5.12)
UPDRS I	1.74 (1.63)	1.61 (1.75)	-	-
UPDRS II	10.53 3.76)	9.47 (4.46)	-	-
UPDRS III	9.15 (3.74)	10.15 (3.00)	-	-
UPDRS IV	4.67 (4.03)	3.89 (3.14)	-	-
ABC	-	-	-	-
FES	12.89 (5.16)	15.00 (7.65) †	10.20 (.63)	10.00 (.0)

Values are means (SD). Abbreviations: BBS, Berg Balance Scale (higher scores on a range from 0-56 indicate better balance); TUG, Timed up and Go; UPDRS, Unified Parkinson's Disease Ratings Scale (I, mentation, behaviour and mood; II, activities of daily living; III, motor symptoms; IV, complications of medication); ABC, Activities-specific Balance Confidence Scale (balance confidence whilst completing daily activities from 0 to 100%); FES, Falls efficacy scale (a higher score on a scale from 10-100 indicates greater fear of falling). * Indicates significant effect of post vs pre, $p <. 05$. † Indicates a significant effect of group (PD vs Non PD) for the social dance study, $p <. 05$

For physical measures there was a significant main effect of time for the Dual TUG. There was a significant main effect of condition for TUG, FES and BBS, p<.05.

The non PD group was at the very bottom of the scale for FES (minimum possible score is 10) and at post testing, all non PD scored 10 on the FES. The PD group did show a small increase in their FES scores, however this was not significantly so. This indicates a decline in confidence regarding falls. The scores on this scale range from 10-100, therefore the PD group were also scoring very low on this scale. This corroborates that none of the participants classed themselves as fallers.

There was a significant interaction between the groups for the Dual TUG F (1, 28) = 6.78, *p*= .015, $\eta\rho^2$=.195. This can be seen in Figure 5.2 such that controls scores increased after the intervention and those with PD decreased.
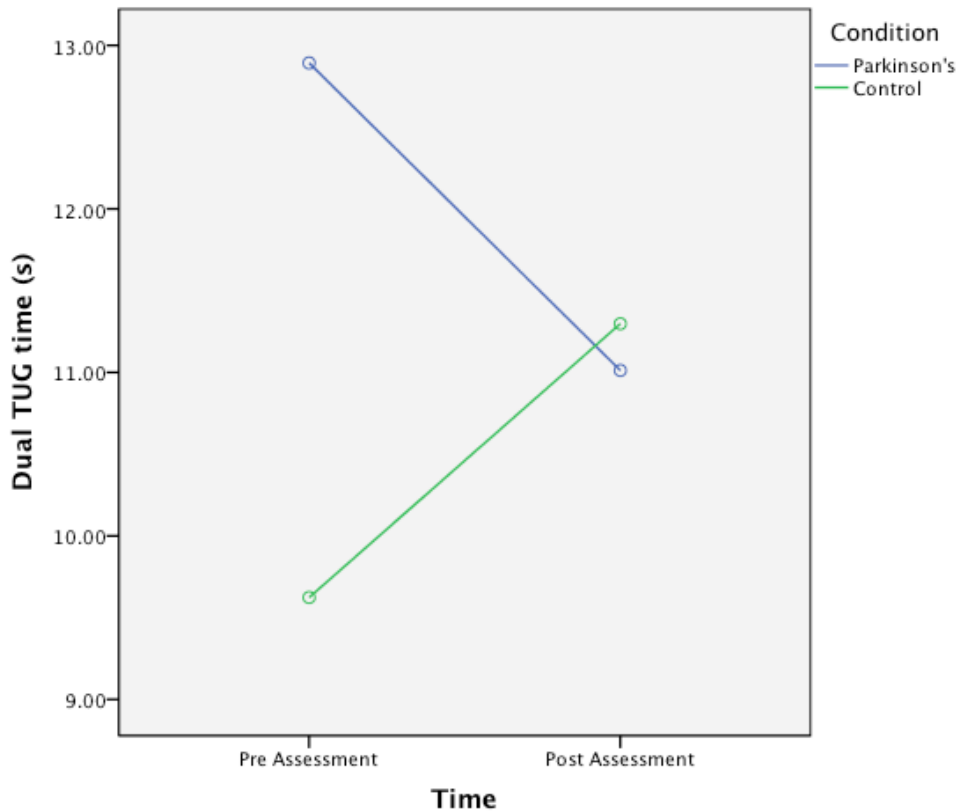
Figure 5.2 Dual TUG scores

Cognitive Tests

The four cognitive tests were analysed using repeated measures ANOVA. The AUT and ATTA were used as measures of Divergent thinking and MRT and LDT were used as measures of Convergent tests. The average scores between two raters were taken for analysis. Originality scores for the ATTA were not computed, as the inter-rater reliability scores were unacceptably low. No significant effects were observed for any of the cognitive tests, p>.05.

For all outcome measures, ANCOVA and MANCOVA (on theoretically linked outcomes, POMS, PDQ-39) were conducted to control for the confound of

medication. For all outcome measures, ANCOVA and MANCOVA revealed no significant differences for time, condition or interaction.

5.3.1 Qualitative results

Two key themes emerged from both the diaries and exit interviews. These were Enjoyment and the effect of music and dance. These can be seen in Figure 5.3
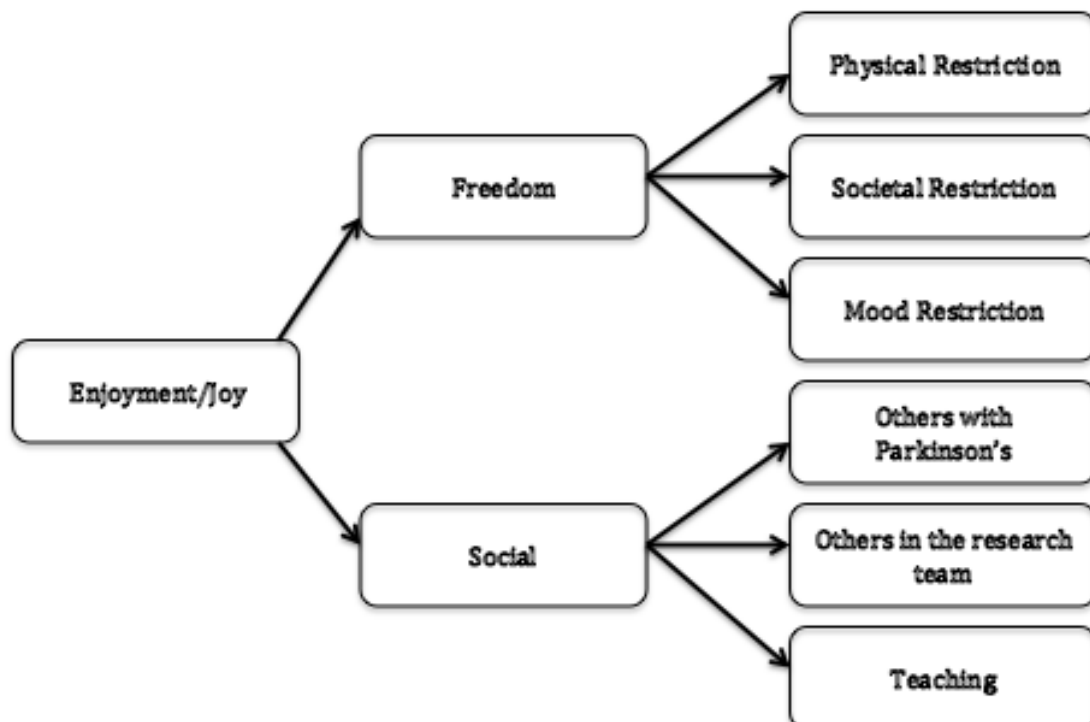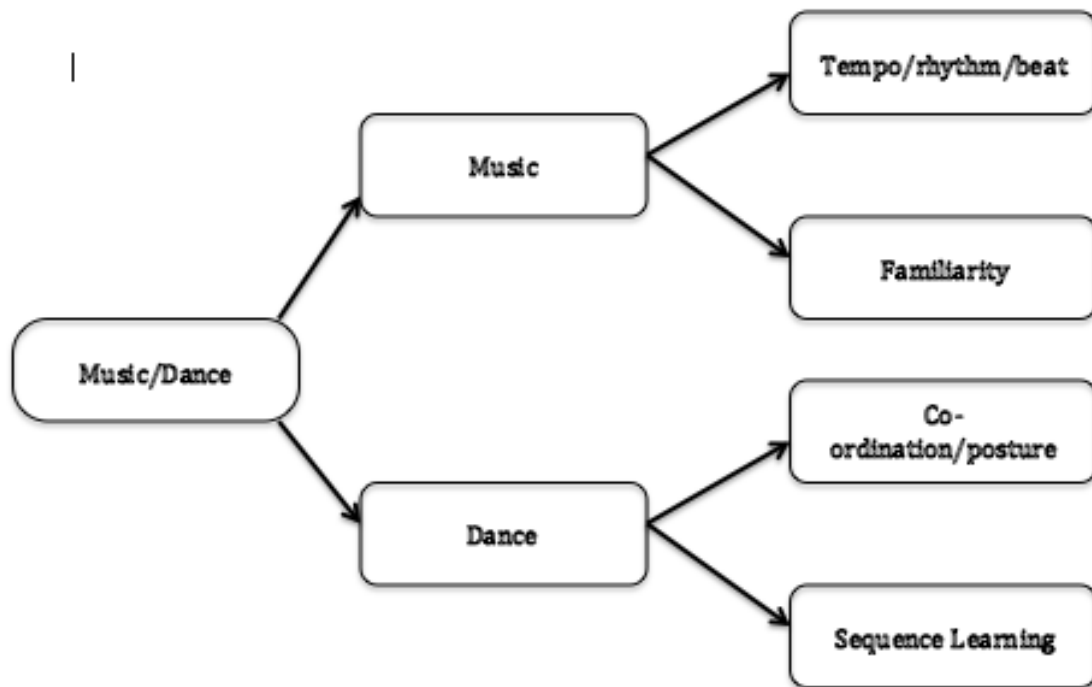
Figure 5.3 Emergent themes

Enjoyment

The strongest theme to emerge from both the diaries and exit interviews was enjoyment/joy. This can be broken down into the enjoyment of social interaction and the freedom from (physical) restriction. Within these two subthemes a number of smaller themes make up the overall picture.

Freedom from Physical Restriction

Participants discussed the ways in which PD had an effect on their bodies, feeling physical restriction.

> *Parkinson's makes me feel restricted anyway.*

The physical symptoms of PD cause problems with mobility and freedom of movement. These were apparent within the dance sessions, with a number of participants discussing frustration with their bodies when trying to move.

> *I hated it [at first] because I couldn't do what I anticipated I could do so I was, they were giving me instructions, I was hearing the instructions knowing what to do but my body just wasn't doing it.*

Participants indicated that the dance did not improve their physical symptoms, the freedom in movement tended to be discussed in terms of memories. Participants felt that being involved in dance reminded them of the past when they were able to move more freely.

But just that sense of freedom that you get [from dance] for those few seconds, they keep you going. They help you remember how it used to be. And those memories erm you can go off places in your memory that your body wont take you.
This was also linked to the class being challenging to participants, forcing them to move in ways they hadn't for sometime.

Yes just the effort of trying and working at it erm and trying to do the steps and thinking you know even if you're body's not moving thinking "that's where your body's got to go come on try" and then I might find the next day I can do it.

Freedom from Social Restriction
Participants discussed feelings of social restriction and stigma in both exit interviews and diaries. Although some participants were already rather sociable, others felt as though their condition had affected their social lives.

I like meet meeting people, quite a sociable sort of character. I have various groups through my activities and err in the end you make a lot of friendships really. And that to me is one of the most important things in life.
There were feelings of stigma and a lack of confidence for participants to be involved in movement and especially movement to a rhythm.

...you know I did have rhythm before I had Parkinson's and I realised I didn't and that was a bit disheartening
A number of participants discussed their ability to be more confident in other social situations following the dance sessions.

My wife and I attended an anniversary party, there was a jazz band, the music was just perfect as far as I was concerned, the sort of music I enjoyed years ago, I did not stop dancing, I was on the floor for sensibly about an hour and a half. People were saying to me 'what are you on?'... And my wife said "you're wearing me out' ... So it was just like a miracle. It was amazing. Absolutely amazing.
Participants discussed their unease at attending social events before the intervention. Towards the end of the dance sessions and predominantly during

the exit interviews, participants expressed an increase in confidence in other people seeing them moving. One couple discussed 'giving up' dance classes in the past following their diagnosis.

We gave up about 9 months ago because it was getting more difficult with certain aspects of it for ??? It isn't dancing as such, we can move, it's the tension, this is back to Parkinson's, the the tension in trying to learn a dance, standing still and listening to someone say " do this, do that" that tension creates a problem..... although we're hoping start after Christmas aren't we because one other couple there have been saying to us go with them on a Sunday once a month.

<u>Freedom from Mood Restriction</u>

Participants overwhelmingly felt as though the dance sessions improved their mood. There was discussion by a number of participants that they were apprehensive at the start of the intervention, by the end of the sessions participants were discussing feeling more positive following the dance sessions.

It gets people out and if if you've, some people feel depressed if they see people enjoying their self it changes their mood doesn't it?

Participants reacted more positively to some sessions than others, this was discussed in terms of personal preference of music and dance styles.

I just did...You know, you feel a bit embarrassed saying but there was just something about his session that left me feeling absolutely joyus for the next three of four days

<u>Others with PD</u>

Although a number of participants had been recruited from local Parkinson's UK groups, some participants expressed hesitation in connecting with others with PD.

I'm always wary about meeting up with lots of other Parkinsonians because one worries that one will see visions of one's future self down the line. But it was considerable amount of solidarity and espirit d'corps built up among the participants. So it was very nice

Participants also shared information regarding other exercise and dance classes that they had been to and other research programmes they had been involved in.

I shield away from meeting other people, because to be perfectly frank, and I think you'll understand this, you don't want to see people worse off than yourself because you think 'well that's going to be me in two or three years time', but oddly enough I don't feel like that now, I think 'that's the way they are and that's the way I am' and its been good because people have told me different things wouldn't have known about and its opened up other avenues…this amazing world that I would have known nothing about.

Teaching and others in the research team

A number of participants discussed enjoyment in meeting the research team and volunteers involved in the research. Participants felt being involved in the research was beneficial for the wider PD community and discussed their feelings towards research for PD in both diaries and interviews, that all research was beneficial for those with PD.

Well I liked meeting meeting all of the your team, I thought that was quite interesting.

The dance sessions were predominantly run by one teacher, although there was a guest teacher for the Music Hall week. For the final week, the session was run by the research team as a round up of all the dances learnt in the previous weeks. Overall, the participants felt the dancing was of a high standard and encouraging to the class.

…Of course erm Holly sort of choreographed magnificently…

There was a feeling of anxiety from participants at the beginning of the sessions due to their physical abilities and what the teacher/ research team would be thinking about them. One participant questioned whether the researchers would be looking at them and thinking '*which of them has it?'* Although, as time went on this appeared to diminish.

I think er it was very good because there was no erm there was no criticism of you really because we were a load of duffers!

Tempo/rhythm/beat

There was quite a disparity between the types of music that participants enjoyed. A number of participants enjoyed a fact paced, strong beat music piece

to dance to. With participants suggesting that the rhythm was beneficial for them to move to, with others finding this too fast and confusing to remember the steps.

I think I like the Black Eyed Pea thing, rather than the Americano, because it was strong, aggressive. The beat seemed to resonate with my body…

This differed to few of the participants that preferred slower, more graceful movements as this allowed time to concentrate on each other movements and using the correct posture.

Familiarity

The role of familiarity appeared important to participants. Both types of dance and music that was familiar to participants were enjoyed more, than unfamiliar styles.

So there was a certain element of familiarity. Erm and the even the leg movements there were a bit stronger, so that seemed to work for me, bit strong leg movements rather than I just don't do walking on the spot very easily. .

Enjoyment of specific dances greatly differed between participants. This was discussed in terms of music preference, with participants tending to enjoy the weeks in which the music was more familiar to them.

Erm I liked the Bollywood because er I like I like the Indian music, we go to India, we sit it and er and we've got CD's of Indian music and that sort of thing

Co-ordination/posture

Lack of co-ordination was discussed by participants. Moving different parts of the body proved difficult for participants, this differed from week to week with more complex dance sequences involving 'heel-toe-heel' for example taking longer to learn and involving more mistakes.

My arms and legs kept getting confused – like someone rubbing his stomach with one hand whilst patting their heads with another

This however, appeared to improve over the weeks, with participants suggesting they enjoyed the differences in speeds.

I found it enjoyable, erm there was a mixture of speeds because the dances differed and the erm and the complexity of the of the dance steps varied for me anyway, at least it appeared to, some were easier than others

The cheerleading week was seen to be the easiest routine to learn, as there were mostly upper body sequences. This was found to be easier for co-ordination by many participants, although some felt this routine was not taxing enough due to the limited lower body movements.

Sequence Learning

Participants felt as though learning the sequence for the dances was cognitively quite difficult.

Was the intervention for us to be dancing or for us to be learning a dance routing? Because what we were doing was learning a dance routine which was a feat of a kind of memory rather than just getting the exercise of doing the dancing

A number of participants expressed feeling that longer should be spent on teaching each of the dances, which would have provide more enjoyment. This is also linked to participants suggesting 'at home' resources to help with practicing, such as a DVD and written sequence. Participants were unsure of whether they should be practicing and for how long.

That's avoidable, you see if you're given a script or a video you can check yourself and get it right

It was also stated that one of the best indicators to change in participant's abilities was the warm up. The warm up was the same sequence each week using the same music. Improvements in performance at the warm up was noticed by participants and commented on by a number.

And another thing I've found is that through the the sessions at the beginning I couldn't do the warm up, by the end I was doing the warm up quite comfortably. So that's interesting because that was a fairly constant thing through all the weeks

Change in symptoms?

Overall participants did not feel as though their physical symptoms had been improved by the intervention. It was indicated that only one hour per week

would not have been long enough to see any physical changes in participants balance and movement.

> *I've not noticed anything, mainly I think because I've not been practising. I don't expect an hour at week to make a lot of difference to me.*

Participants were also asked whether they felt the dance sessions had an impact on mood. The majority of participants felt they had an improvement in feelings of mood, albeit for a short time frame following the sessions. Thirteen out of the 8 interviews indicated a positive change in mood following the dance sessions.

> *At the end of it, completely different, really confident, and buoyant and and fired up and I suppose the adrenaline was pumping and again a lot of that through the fun of being part of a group and watching the whole group together. So have U felt better at 7 o'clock than I did at 6 o'clock? Absolutely, yes.*

Of the group, four participants indicated they could not tell if there were any changes in mood and one felt a negative effect on mood.

Overall feelings

Participants overall had overwhelming feelings of enjoyment towards the current study. Participants discussed feeling freedom from physical, social and mood restrictions when completing the current research. Participants enjoyed being part of a social group with others with PD as well as spouses and partners. Participants enjoyed the teaching style and the range of dances, although participants had reservations regarding teaching space and number of sessions per week.

Participants also enjoyed the music and dances that were included in the sessions, noticeably the familiarity of the music. Participants discussed co-ordination and that they felt uncoordinated at times. Learning sequences not only involved completing exercise but also a cognitive element for remembering the steps.

Feelings of increased mood were observed by a number of participants, which is in line with quantitative findings. With both short and long term mood improvements following the sessions. Participants felt as though they did not have physical changes after the sessions, which is in line with quantitative data showing no balance improvements.

5.4 Discussion

5.4.1 Main findings

There were a number of significant improvements in mood following the social dance sessions, both in long cycle and short cycle mood assessments. Over the length of the intervention, feelings of tension-anxiety, anger-hostility and fatigue-inertia decreased significantly. Levels of vigor-activity increased and overall mood improved. Assessments of short term changes in mood also identified improvements, with tension-anxiety decreasing, vigor-activity increasing and overall mood improving. These improvements were significant over time with no main effect of condition or interaction. This suggests that all participants, regardless of whether they have PD or not can have improved mood after dancing. Not only are these improvements visible after a number of sessions, but there are also immediate mood effects of the dance classes. This finding suggests that dancing is a mood improving activity and the effects can be seen by both those with or without PD, this has real world implications that both those with PD and their partners can enjoy dancing and both parties reap the benefits. This finding links back to the dance and mood literature that suggested dance can be immediately beneficial after a dance session (Lane et al., 2003; McInman & Berger, 1993). Music showed immediate improvements following dance in the current study. There was also a significant improvement in mood for participants up to a week after the last dance class (at the post assessment session). This differs from previous research in the elderly that indicated that dance does not have an effect on depressed mood. It may be the case that the depression measures used in these research papers (Eyigor et al., 2006; Alpert et al., 2006) were not sensitive enough to pick up changes in overall mood. These findings suggest that dance has a benefit in mood for those with PD both immediately, but also up to a week after the last session.

In terms of quality of life, there was only one subscale showing a significant improvement. Participants felt they had improved communication after the intervention compared to before the intervention. This may be due to the social aspects of the dance classes. Participants in a number of cases were not used to

socialising with others with PD and have actively made the decision not to interact with others with PD.

I'm always wary about meeting up with lots of other Parkinsonians because one worries that one will see visions of one's future self further down the line. But it was considerable amount of solidarity and espirit d'sorps built up among the participants. So it was very nice.

This may have aided in improved feelings of communication related to the disease itself and discussing it with others. An alternative view could also be that improvements in communication could be indirect due to improvements in mood aiding communication. Those with reduced feelings of tension-anxiety and anger-hostility are more likely to feel more comfortable communicating with others. This could be linked to the broaden and build theory (Frederickson, 2001) that suggests an increase in positive emotions affects a persons thought-action behaviour. An increase in certain emotions can promote engagement in new, creative ideas and social interactions (Frederickson, 2001). This improvement in mood may have an effect on participants that they are communicating more effectively.

For the FES, there was a significant main effect of condition. This suggests that those in the PD group had significantly less confidence in their balance in a number of daily activities/ situations. This is to be expected in when comparing these two groups. A main effect of condition with no main effect of time or interaction was also seen in the BBS and the TUG. This shows that a number of the balance and physical measures showed no improvement, but that those with PD were scoring significantly lower than those that did not have PD.

In the Dual TUG, there was no significant main effect of time or group, but there was an interaction. This suggests that those with PD improved and Non PD were actually slower at completing the task at the final assessments compared with the initial assessments.

In order to attempt to statistically control for the confound of medication, ANCOVA and MANCOVA were run for all outcome measures. No significant differences were observed for any outcome measure following this analysis. This may suggest that differences over time and between groups may have been affected by medication and when this was controlled for, these differences were negligible. The limitations of this analysis are discussed in section 10.7.

It is difficult to establish whether the effects were solely from the dance sessions or whether being involved in a social group once or twice weekly had beneficial effects on mood and quality of life. During study one, participants were given diaries to take home to write any thoughts or feelings they had. Participants were not given detailed instructions and therefore could write anything they felt relevant to the research team. Semi-structured interviews also took place after the final assessment session to discuss how they felt about the research. Qualitative findings suggested participants discussed two main themes, enjoyment and music/dance. Within these themes a number of subthemes became apparent.

Physical benefits were discussed in both the diaries and interviews including: better sleep, feeling more flexible, using muscles not used for a while, shuffling less and using skills of managing close footwork when loosing balance in everyday life situations. In line with the quantitative findings, participants recognised they were not expecting to see physical change following just ten weeks of dancing, especially taking into account the other activities that some participants undertook on a regular basis. Participants reported the sense of enjoyment and joy that was experienced whilst completing the research project, see figure 5.3.

Within music and dance a number of sub-themes emerged, including tempo, familiarity of the music used, co-ordinated movements and learning different dance sequences. All the participants referred in different ways to the tempo/beat of the different styles of music and how this made them want to dance or not. In terms of familiarity, participants appeared to enjoy the music

that had a resonance from their past. The role of music evoked strong emotions from participants such as 'loved' or 'hated'. Co-ordination featured within the analysis, coordinating different body part at the same time proved difficult for some but for most this did improve as the sessions continued. As for co-ordination, sequence learning was difficult for most at the beginning of the dance sessions, this did improve for many as the weeks continued.

Within dance and music, none of the sub-themes were linked to demographics within the group including age, gender or disease severity. Instead, strong emotions about the dances were more related to a personal and individual response.

Within both their diary entries and their exit interviews, participants reported the sense of enjoyment and joy that was experienced. This joy was related to accomplishing personal freedoms, as well as enjoyment from being part of a group. Within freedom, restriction of their body, of opinions within society and increase in mood featured heavily. Physical restriction refers to participants enjoying their body, moving to music in a way that it wouldn't normally do; and the link with remembering the movements their body used to be able to do. Participants also discussed the stigma of their bodies not moving in a way that is socially accepted and the joy of improving confidence of moving to music. Participants also discussed improvements in mood after dance classes.

Figure 5.3. also shows the role of being part of a social group as a sub-theme. Within the social aspect of the dance sessions, participants discussed socialising with others with PD, the research team and dance teacher. This social factor was found to be a theme of enjoyment within the classes. Although some participants in the group had regular contact with others that have PD, this was not the case for all. Participants enjoyed meeting others with PD, even those that were dubious and actively decided not to interact with others with the disease, not wanting to see what the future holds. Joy was also described from the wider group of the teachers and research team. Many participants commented on the feeling of value at being part of a research group, which could potentially have

benefits for others with PD. There has been minimal qualitative research conducted into dance and PD. Houston and McGill (2013) conducted a mixed method study into the effects of ballet on those with PD. Results found that participants described some physical improvements following the sessions, both for balance and rigidity. Participants also felt highly motivated and had an increase in confidence. Participants reported an increase in feelings of wellbeing and enjoyed the social aspect of the classes. These findings link with the mood improvements seen in the current study and those described in the qualitative section of this study.. This study shows that that the findings are similar in terms of enjoyment.

The role of a social group was discussed in depth and made up one of the four sub-themes of this study. This would suggest that social groups and activities had a large effect on how people felt towards the dance classes. This may suggest that it may have been part of a social group that benefitted participants in terms of outcome measures rather than solely the dance classes. Diaries collected from those participants in study one discussed that participants, in some cases, did not socialise with others with PD before the study. As the dance sessions were group based, participants may have had improvements in mood due to the social aspects of the sessions. Therefore, study two aims to investigate whether social interaction is a factor influencing the effects of dance.

The question remains, is it that people are enjoying the social interaction, which is having an effect on outcome measures such as mood and quality of life? Therefore this research is aiming to answer the question, is there a difference in outcome measures for those that are socially active?

Findings suggested that participants did not feel as though they benefitted physically from the dance sessions. This is in line with the findings from the quantitative research that showed no changes in balance following the dance sessions.

5.4.2 limitations

One reason why the current study showed a differing pattern of results to previous research may be the format of the dance sessions. Every second week the dance style changed in study one. This may have led to an increased cognitive load. Participants may not have practiced the dance enough to become comfortable and familiar with it. Brown, Martinez and Parson's (2006) suggested that the putamen becomes activated in a PET scan when amateur dancers moved their feet to music simulating dance steps. It has been suggested that those with PD have greater dopamine loss from the Putamen than from other regions in the striatum earlier in the disease. Therefore, becoming trained in dance by completing a number of dance sessions, learning and perfecting specific components of a dance, may actually activate the putamen that has been damaged from the disease.

Participants in study one, had milder symptoms of PD than participants in the previous research. Mean scores for Hoehn and Yahr for the current studies were 1.2 and 1.9 respectively. These differ to Hoehn & Yahr scores of between 2 and 2.5 in the majority of previous research (Hackney et al. 2007ab, Hackney & Earhart, 2009abcd). It may be that changes in BBS scores were more applicable for the previous research, as participants were more severely affected by symptoms before the intervention. This would suggest that greater benefits may be seen in terms of balance for those with more advanced PD than the participants in the current studies.

In terms of intervention length, study one has shown significant improvements on non physical measures (such as quality of life and mood) and little change in mobility and balance. This shows that participants respond positively to the intervention. In terms of physical measures, is it realistic to expect a significant improvement in balance in this population after an hour a week dancing for only 10 weeks? Hackney & Earhart (2009b, 2009c, 2009d) also used a 10 week intervention programme, however this was two sessions per week. The effect of study one may have been too diluted with only 50 minutes of dance per week. A more frequent intervention would be a more realistic expectation for showing an

effect on mobility and balance in those mildly effected by PD. An intervention that is only one session per week may be too little for participants to note any beneficial effects. In the future, an intervention more frequent than once per week and for a longer period of time would be useful to examine.

The results of study one differ to those identified by Hackney et al.(2007a, 2007b) and Hackney & Earhart (2009b, 2009c, 2009d). This study failed to show improvement in balance or mobility measures as the previous research. There could be a number of reasons for this. The most obvious would be dance style with Hackney & Earhart have predominantly used the Argentine tango compared to a variety of structured dances. The second reason is length of intervention.

Overall, study one showed an interesting pattern of results. Both long and short cycle mood improvements were observed following the dance sessions. There were limited physical and cognitive changes following social dances. This study tells us that participants enjoyed the intervention, but that they showed no changes in balance, mobility or cognition. This study raises a number of questions:

- **Was it the social aspect of the study rather than the dancing that brought about the observed mood improvements?**
- **In a real world setting, are those with PD completing regular dance classes any happier or more mobile than those that don't?**
- **What is the effect of music on participants?**

Chapter 6: Are there differences in mood of people with PD completing different social activities?

6.1 Introduction

The purpose of the project was to investigate the level of social interaction that those with PD participate in, more specifically the role of social support and social activities on mood. This study aims to investigate whether mood differs depending on the type of social activity those with PD participate in.

Findings from the previous studies have raised a number of questions regarding the effect of dance on outcome measures in those with PD. So far, it has been difficult to establish whether the effects were solely from the dance sessions or whether being involved in a social group once or twice weekly had beneficial effects on mood and quality of life. Qualitative findings from study one suggested that participant's feelings toward the study fell into two main themes, enjoyment and music/dance. Within these themes a number of subthemes became apparent.

Within the sub themes, both in the diaries and exit interviews, the role of the social group was discussed. Participants reported the sense of enjoyment and joy that was experienced. This joy was related to accomplishing personal freedoms, as well as enjoyment from being part of a group.

The role of a social group was discussed in depth and made up one of the four sub-themes of this study. This would suggest that social groups and activities had an effect on how people felt towards the dance classes.. Diaries collected from those participants in study one discussed that participants, in some cases, did not socialise with others with PD before the study. As the dance sessions were group based, participants may have had improvements in mood due to the social aspects of the sessions. Therefore, study two aims to investigate levels of social interaction that those with PD engage in.

The question remains; is it that people are enjoying the social interaction, which in turn has a positive effect on mood? Therefore this research is aiming to answer the question, is there a difference in mood for those that are socially active?

6.1.1 Previous Literature

Previous research has investigated health outcomes on those with PD using qualitative analysis (Chiong-Rivero et al., 2011). Through focus groups, sub themes emerged including stigma, coping mechanisms and changes in social function. This study of 48 participants and their caregivers suggested that those with PD have fewer social resources than before they had the disease. Symptoms such as hypophonia (soft voice) and the decrease in ability to communicate verbally, have lead to a loss of social networks, social roles and self-identity. Krause and Jay (1991) also found that older people in general tend to have fewer social resources. This research has suggested that those with PD may have a fewer social resources post diagnosis. This is important as social interaction has been suggested to have a number of benefits for the elderly. The role of social support was shown to have an effect on levels of cognitive decline in the elderly (Barnes, Mendes de Leon, Wilson, Bienias & Evans, 2004). In a study of over 6000 elderly participants, interviews and cognitive assessments were collected five years apart. It was found that there was a significantly lower instance of cognitive decline in those with increased social resources and those participating in social activities. This study suggests that social engagement may have a protective effect against cognitive decline. This study however, shows the association between level of social resources and cognitive decline and therefore cannot infer causation. It is unknown whether fewer social resources cause cognitive decline or as cognitive decline develops social resources diminish. For those with PD, around 70% of those with the disease go on to develop some cognitive decline, therefore the role of social support in this group may be especially important.

Research regarding the effect of social support on physical and psychological wellbeing, as well as quality of life (Schreurs, Ridder & Bensing, 2000; Brod,

Mendelsohn & Roberts, 1998) has suggested that social support is beneficial for those with PD. This however, has not been found in all outcome measures and may be specific to certain aspects of the disease. Grundy & Slogett (2003) found that social interaction had the largest effect on self rated health (as measured by the General Health Questionnaire) in those aged 65-82, such that those with a lack of social resources had poorer general health. This suggests that those with greater social support perceive themselves to be healthier than those without that support. This study also found that those widowed, had significantly worse general health than married counterparts. There is also evidence to suggest that greater social support was associated with lower levels of both motor and psychological severity in those with PD (Brod, Mendelsohn & Roberts, 1998). However, no effects were seen for cognitive and global severity. This research would suggest that social support may have an effect on both wellbeing and physical symptoms of PD, but the effects are not clear cut. This was further supported by Speer (1993) who suggested that more social activity was associated with fewer physical complaints in those with PD.

However, not all research has shown benefits for those with higher social resources, (Schreurs, Ridder & Bensing, 2000; Roberts, Cox, Shannon & Wells, 1994) and has suggested that social support was not related to outcome measures in PD. Schreurs et al. (2000) conducted a one year longitudinal study investigating coping strategies and social support on quality of life in those with PD. It was found that participants were not seeking social support as a coping strategy and the social support they were receiving, did not have an effect on their overall quality of life. Negative social interactions were also related to problems in psychological functioning in PD (Schreus et al., 2000). This was also investigated in the elderly. Roberts et al. (1994) found that social support did not have an effect on strain, stressful life events and psychological wellbeing in a sample of 153 individuals.

These findings suggest that those with PD may benefit psychologically from increased social support. It is not clear to what degree social interaction has an effect on these outcome measures and whether other factors within social

interaction are involved or indeed cause and effect. Perceived quality of social interactions rather than the frequency (who the interactions are with) may have an important effect. It may be the case that those with PD benefit from support from socialising with others that have the disease. Those that participate in social interaction may be in fact more active (and participating in more active interactions), which may indirectly lead to increased physical and psychological functioning. The association between social interaction and depression has been noted several times in those with PD (Speer, 1993; Brod, Mendelsohn & Roberts, 1998).

This study aims to investigate the association between social interaction and mood levels in those with PD. This study will compare four different PD groups that are currently involved in social activities in order to investigate whether they differ in levels of mood.

Groups:

- No social activities. Those that indicated they engaged in no social groups were included in this group.
- Dance group. Participants that regularly engaged in dance sessions were included in this group.
- Exercise group. All participants that attended a regular exercise class were included in this group.
- Non physical activities group. Participants that attended social groups that involved no physical activity were included here. This includes church groups, book and knitting clubs etc.

The POMS mood measure was administered in order to identify whether different social activities in the real world have an association with mood.

6.2 Method

6.2.1 Participants

Participants were 37 males and 39 females (N=76) diagnosed with PD. Each participant rated themselves for disease severity, with participants ranging from

I to IV on the Hoehn & Yahr scale (Hoehn & Yahr, 1967). Participants were recruited from a number of online networks. The first stage of recruitment was to contact the leaders of local Parkinson's UK groups and invite them to distribute the link to the survey to any members interested in taking part. The link was also posted on the online research forum within the Parkinson's UK website as well as a number of local forums and message boards not associated with those with PD. Parkinson's UK dance and PD groups were attended to promote the study. Emails were also sent to previous participants that had indicated they would like to be contacted for future research. Hard copies were also sent out to interested participants with no internet access. Recruitment aimed to reach a range of participants with PD, and not only those attending Parkinson's UK support groups.

Participants categorised themselves into one of the four groups, by indicating the social activities they completed on a monthly basis. Participants were classified into groups depending on their level of activity. Participants were required to complete at least one hour of activity per week for them to be included in that category. If participants completed two different social activities, the activity with the highest levels of participation was taken. For example: if a participants completed an exercise once a week but also attended a support group once a month, that person would be assigned to the exercise condition.

6.2.2 Measures

After reading the information sheet and giving informed consent, participants were asked a number of demographic questions. This included specific PD information regarding medication, length of time since diagnosis, side of onset etc. Participants completed the Hoehn and Yahr scale (Hoehn & Yahr, 1967) as a measure of disease severity.

Participants completed the POMS (McNair, Lorr, & Droppleman, 1971) to determine global mood scores. In order to assess levels of social resources, questions regarding attendance at support groups and social activities were completed.

6.2.3 Design

This study is a between cross sectional survey design with one independent variable: Group, with four levels (No social activity, dance, exercise and non physical activity). The dependent variable is mood score (POMS). A description of the POMS can be seen in chapter 3.

6.2.4 Hypotheses

- Those completing regular social activites will have a higher mood than those not completing social activities
- Those completing regular dance sessions will have higher mood scores than those completing other social activities

6.2.5 Procedures

Study two took the form of an online survey, hosted by Bristol online Survey (BOS). Participants were given the link to the survey (https://sdu-surveys.herts.ac.uk/parkinsons) to complete at a convenient time. After reading the information sheet and the consent form, the participants completed the survey. Participants were then debriefed and given contact details of local charities specialising in dealing with depression and mood disturbances as well as PD specific charities. Hard copies of the survey were passed to those without access to the internet.

6.2.6 Statistical analyses

In order to determine whether groups differed, data were analysed using both ANOVA and MANOVA. MANOVA was conducted on dependent variables that were theoretically grouped (POMS dimensions). ANOVA was conducted on the POMS Total mood disturbance score. MANOVA is used in order to protect against type 1 errors, multiple repeated measures ANOVA would inflate this. As repeated measures ANOVA were conducted, Partial-eta squared are reported as a measure of effect size.

6.2.7 Ethics

Ethical approval was obtained from the School of Psychology Ethics Committee at the University of Hertfordshire. Registration Protocol Number: **PSY/01/13/AH.**

6.3 Results

Participants were 76 individuals with PD. Participants ranged from stages 1 (mild PD) to IV (moderate-severe PD) on the Hoehn & Yahr scale (Hoehn & Yahr, 1967). Gender was approximately matched with 37 males and 39 females, age was normally distributed, ranging from ages 33 and 88 (skewness -.57, kurtosis .28). The majority of the participants were receiving medication for their condition (medication N=72, non-medication N=4). Twelve participants were taking antidepressant medications, compared to 64 that were not. Table 6.1. shows demographic information between the four groups.

Table 6.1. Demographic information

	None	**Exercise**	**Dance**	**Other**
N	29	18	22	7
Age	55.66 (9.61)	64.44 (8.62)	72 (7.56)	65.71 (9.95)
H&Y	2.10 (1.2)	2.3 (.97)	2.2 (1.18)	1.93 (1.17)
Years with PD	5.45 (4.47)	6.94 (5.03)	5.58 (3.57)	4.71 (2.81)

All data are M (SD).

Univariate ANOVA's were conducted on baseline scores for demographics. The groups differed significantly in age, $F(3,75) = 14.56$, $p<001$, $np^2=.38$. Follow up analysis with Bonferroni correction concluded that the no activity group was significantly younger than the other three groups. Disease severity and years with the disease did not show any significant differences between the four groups ($p>.05$). Table 6.1. shows that participants in all four groups had mild PD, with a mean of around two, indicating some balance problems but individuals are physically independent.

Participants were all taking medication for their PD symptoms. Table 6.2. shows the variety of medications being taken by participants.

Table 6.2. Medication taken by participants

Medication	Frequency
Levodopa only	14
Dopamine Agonist only	13
Levodopa and Dopamine Agonist	24
Dopamine Agonist and MAO B Inhibitor	5
Dopamine Agonist, Levodopa and MAO B inhibitor	3
Levodopa and MAO B inhibitor	3
MAO B inhibitor	2
Other	8
None	4

*MAO B = Selective Monoamine Oxidase inhibitors

Medication levels in the current study are in line with expectations, with Levodopa, Dopamine Agonists and a combination of the two being the most popularly prescribed drugs, with 70% of the sample having these medications. It is worth noting that Dopamine Agonists are well documented to have some cognitive side effects such as hallucinations, delusions and confusion, which could have an effect on mood outcome measures. These type of cognitive side effects are not seen in the other medications participants in this study were receiving. One participant was receiving Catecholomethyl Transferase inhibitor (COMT) and another taking Anticholinergics for the disease. Both were prescribed with Levodopa.

Table 6.3. POMS Mean (SD) scores for the social groups

	None	Exercise	Dance	Other
N	29	18	22	7
Tension - Anxiety	12.62 (7.11)	11.67 (6.16)	10.23 (5.13)	10.86(8.23)
Depression - Dejection	14.10 (13.32)	11.44 (7.65)	9.59 (6.49)	6.86 (5.90)
Anger - Hostility	9.93 (8.53)	6.06 (4.99)	5.91 (4.55)	4.57 (3.60)
Vigour - Activity	12.93 (7.45)	13.22 (6.15)	12.50 (5.65)	14.43 (7)
Fatigue - Inertia	11.90 (8.05)	11.72 (7.50)	9.77 (5.36)	6.71 (5.77)
Confusion - Bewilderment	8.24 (6.33)	8.28 (4.80)	8.45 (4.84)	7.43 (4.39)
Total Mood Disturbance	43.86 (44.21)	35.94 (28.06)	31.45 (24.96)	22 (25.42)

All data are M (SD).

Table 6.3 shows mean scores for the POMS dimensions and total mood scores for the four social groups. Scores appear fairly consistent for the different social groups. Statistical analysis comparing these groups can be seen below.

A Univariate ANOVA was conducted for group on the outcome measure POMS TMD. Analysis of variance did not show a main effect of group for POMS TMD, $F(3,72) = 1.02$, $p= .390$, $np^2= .041$, suggesting that total mood score did not differ depending on social group.

A MANOVA was conducted for group on the POMS dimensions. A one way MANOVA revealed no significant difference between model scores for the groups, Wilks' $\lambda = (18,189.90) = 1.14$, $p=.316$, $np^2=.092$. This suggests that mood was not associated with social group.

In order to investigate whether difference in hours of social activity was related to mood, regardless of type of activity, participants were split into four groups. These groups were, no activity, four or less hours per month, eight hours or less per month, and more than eight hours per month.

A Univariate ANOVA was conducted for hours per month of social activity for POMS TMD. Analysis of variance did not show a main effect of group for POMS TMD, $F(3,67) = .655$, $p= .583$, $np^2= .028$, suggesting that total mood score did not differ depending on social hours per month.

A MANOVA was conducted for number of hours of social activity per month on the POMS dimensions. A one way MANOVA revealed no significant difference between model scores for the groups, Wilks' $\lambda = (18,175.848) = 1.521$, $p=.087$, $np^2=.127$. This suggests there is a trend towards differences within the model, however follow up Univariate ANOVA's did not show any signficant effects of the dimensions. This suggests that group did not have an effect on levels of mood.

6.4 Discussion

This study aimed to investigate whether social interaction was associated with mood. Main findings of this study were that levels of mood were not related to participants taking part in different social activities.

Analysis was also conducted on these outcome measures for the number of hours of social activity participants were completing over a one month period. Both ANOVA and MANOVA revealed no significant differences between those that completed no activity, four or less hours per month, eight hours or less or more than eight hours of activity per month. There was a significant difference in age of those completing social activities. Those that were not completing any social activity were significantly younger than the other three groups (exercise, dance and other). Participants did not differ in term of disease severity or length of time with the disease.

These findings suggest that those completing different types of activity do not differ in mood. This would indicate that those completing dance for PD do not show any differences than those completing different social activities. The levels of social activity that participants completed per week did not show any change on the outcome measures. This would suggest that our results are more in line

with Roberts et al. (1994) and Schreurs et al. (2000) that have also found no differences in mood and quality of life between those with high and low social resources.

In comparison to findings of study one, participants in the current study had lower mood scores in all dimensions. These can be seen in table. 6.4.

Table 6.4. POMS Mean (SD) scores for the social groups and post scores from study one

	None	**Exercise**	**Dance**	**Other**	**Study one Post**
Tension - Anxiety	12.62 (7.11)	11.67 (6.16)	10.23 (5.13)	10.86 (8.23)	7.67 (5.16)
Depression - Dejection	14.10 (13.32)	11.44 (7.65)	9.59 (6.49)	6.86 (5.90)	6.89 (8.12)
Anger - Hostility	9.93 (8.53)	6.06 (4.99)	5.91 (4.55)	4.57 (3.60)	5.16 (5)
Vigour - Activity	12.93 (7.45)	13.22 (6.15)	12.50 (5.65)	14.43 (7)	16.78 (7.4)
Fatigue - Inertia	11.90 (8.05)	11.72 (7.50)	9.77 (5.36)	6.71 (5.77)	8.11 (5.64)
Confusion - Bewilderment	8.24 (6.33)	8.28 (4.80)	8.45 (4.84)	7.43 (4.39)	6.06 (4.49)
Total Mood Disturbance	43.86 (44.21)	35.94 (28.06)	31.45 (24.96)	22 (25.42)	17 (30.58)

All data are M (SD).

Data from table. 6.4 shows that mood scores of participants completing different social activities do not differ and are lower than we found in study one in the laboratory.

One reason for this finding may be that participants completed the survey at their convenience. Study one found immediate and longer term mood

improvements after dance. It is unknown the length of time after activity participants completed the survey, and could have potentially been a week or longer. It may be that mood improvements are relatively short lived and therefore are not observed in the current study. As length of time since activity was not controlled, it is difficult to know whether participants had a short term benefit of social activity which has since diminished.

Also, this survey used a self report format, without the instruction of the researcher. Although the instructions were described as clearly as possible, it may be that participants were unclear as to what activities were to be included in the questionnaire. Participants were asked to answer questions on mood as well as self report their level of severity (Hoehn & Yahr scale). Leritz, Loftis, Crucian, Friedman & Bowers (2004) suggested that basal ganglia dysfunction in those with PD may have an effect on their ability to accurately rate the severity of their symptoms. Lertiz et al. (2004) found that participants with PD rated themselves as higher functioning than their caregivers on scales of activities of daily living.

Interestingly, it was more difficult than expected to recruit participants that were completing a dance class. This may suggest that dance is not a common social activity that those with PD participate in. As this is an online survey, it is unknown which area of the UK participants reside. It is known that there are some areas such as London where PD and dance classes are available, but this is not consistent throughout the country (Luck, 2012). It may be that dance classes are not readily available to all with PD. It would be interesting in the future to investigate barriers as to why those with PD are not engaging with dance, could there be lack of availability, poor advertisement, lack of transport?
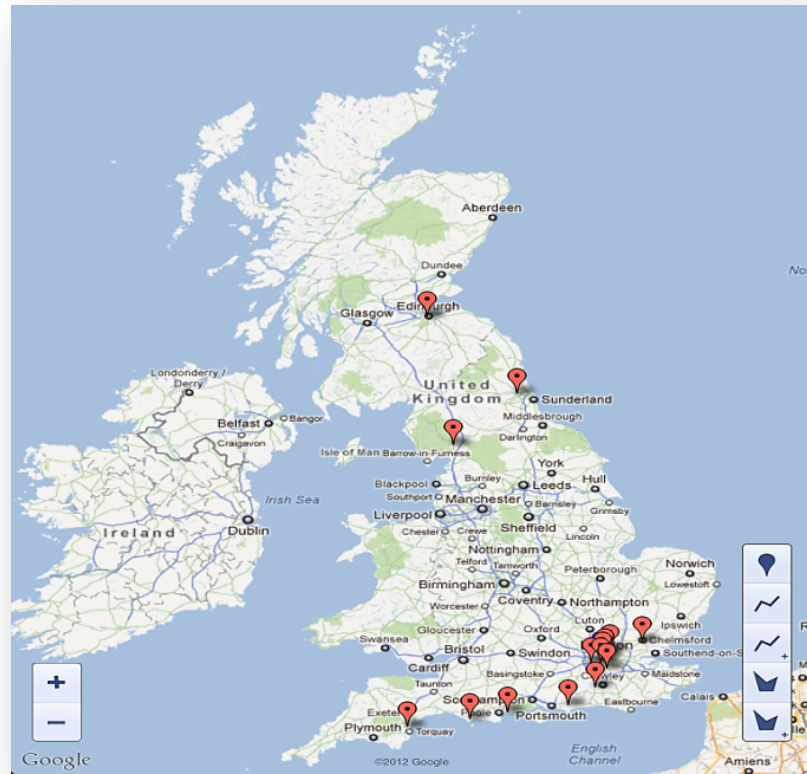
Figure 6.1 Availability of dance for PD classes as of May 2012 (Luck, 2012 unpublished)

Figure 6.1shows the lack of PD and dance classes in northern UK. The classes that are available are clustered around London and the south west. There are only three classes available north of London. This suggests that the availability of classes is minimal which may be why many people with PD may not be participating in this activity.

This study did show that half the participants were engaging in some social activities. Surprisingly, it was found that younger individuals tended to be less involved with social activities. This may be that younger people with PD could still be working and therefore have less time for social activities. Information regarding employment status was not obtained and therefore it is unknown how many of the participants were still working. This is a confounding variable on these results, as attending work would likely result in social interaction with

others. It may also be that younger people are less likely to attend social activities organised for those with PD. The two most common activities included attending support groups (Parkinson's UK groups) and exercise classes. This is to be expected as exercise has been widely publicised for its benefits for PD.

One issue in the current study has been recruitment. This study focused on the social activities that those with PD in the UK participate in. Therefore, the study aimed to recruit a representative sample of those with PD. In order to recruit participants, a number of Parkinson's UK networks were used. These were very useful and helped to recruit many participants. However, these participants could be said to be more interested in research and attending Parkinson's UK support groups as they belong to mailing lists/support networks. Therefore, even the participants that did not complete any social activity (the no activity group) may be more interested in research and therefore this is why they were members of Parkinson's UK message boards and also willing to take part in research. These participants may not actually be representative of those that are not completing social activities and may be socially isolated.

Participants included members of the Parkinson's UK support group, although many do not attend their local sessions. It was very difficult during the recruitment process to enlist participants with PD through channels not set up by Parkinson's UK. The PUK message board forum's and research network were valuable networks to recruit participants, but they may not be entirely reflective of the general population of those with PD. This could have potentially skewed our sample to those more involved in social activities within Parkinson's UK. Unfortunately, it is difficult to ascertain whether this is the case.

The findings of the current study suggest that type or amount of social activity had no effect on mood. Comparing these with those of study one, this differing pattern of results suggest it is important to investigate the effect of dance and exercise on mood more specifically in follow up studies. Study one found improvements in mood following dance, but study two found that those dancing in a 'real world' setting had no difference in mood from other groups. This

pattern of results is not clear and further research is required to investigate how music, movement and social aspects of dance have an effect on mood.

Chapter 7: Does music and movement affect mood in people with PD?

7.1 Introduction

The previous studies in this programme of research have found a number of interesting results. Following a dance intervention participants with PD showed improvements in quality of life and mood. These studies were the first studies to investigate psychological measures and suggested that dance can bring about non motor changes in those with PD. These findings lead to a number of questions centring around the role of music, exercise and social interaction. Study two investigated mood in different social groups in a real world setting. This study found no difference in mood between the groups, including dance. The pattern of results between study one and two is unclear. In a lab based study, mood was improved following dance, but when investigating the association between mood and social activities including dance, no changes between activities were seen. Mood levels for social groups in study two were lower than those observed following dance in study one. As length of time since last activity was not controlled in study two, findings suggest that changes in mood following dance may last for a relatively short term and not globally improve mood.

The current study aims to investigate whether mood changes can be observed immediately after completing a music and movement activity without the social context of a group class. This study will determine whether mood changes can be seen immediately after completing this activity, this mirrors the immediate mood changes following the dance session in study one.

7.1.1 Previous Literature

Exercise has previously been found to have a beneficial effect on those with PD (Shulman et al. 2013). It has been suggested that exercise is beneficial for physical symptoms but has selective effects on mood, quality of life and cognitive function. Previous research has suggested that exercise can have immediate positive effects on mood (Swartzberg, 2011). This has been especially seen in

clinical populations, such as those with depression (Byrne & Byrne, 1993; Lane & Lovejoy, 2001). Lane & Lovejoy (2001) found evidence that aerobic dance can provide significant improvements in mood, as measured by the POMS-A (which later was modified into the BRUMS mood measure). Significant improvements were observed on four out of the five dimensions measured (tension-anxiety, anger-hostility, vigor-activity and confusion-bewilderment) were observed for both depressed and non depressed participants, with a main effect of time. There was however, an interaction between depressed and non depressed groups on all dimensions such that the depressed group showed greater improvements than the non depressed group. This research suggests that those with and without depression can benefit from aerobic dance, although those with depression may see a larger benefit.

A meta-analyses conducted by Netz, Wu, Becker and Tenenbaum (2005) suggested that physical activity had a significant effect on the wellbeing of older adults, this meta analysis included studies investigating a range of outcome measures that make up general wellbeing. Four categories: emotions, general wellbeing, bodily wellbeing and self perceptions were used to categorise studies, with each of these including a range of outcome measures. This meta-analysis suggested that exercise has a beneficial effect on general wellbeing, with both aerobic and resistant training showing significant improvements over time. There was however, a suggestion that aerobic training may be more beneficial for improving feelings of depression.

A review conducted by Crizzle and Newhouse (2006) suggested that those with PD could observe physical improvements following exercise. The review suggested that although further research was required to investigate this sample in a robust fashion to determine whether those with PD could physically benefit from participating in exercise.

More recently Shulman et al. (2013) demonstrated that exercise can be beneficial for physical improvements in PD. This study required participants with PD to complete one of three exercises, three times a week for three months.

Participants were assigned to either high intensity treadmill training, low intensity treadmill training or strength and flexibility training. All three of the training interventions showed significant improvements in the 6MWT. Both the treadmill training groups had a significant improvement in cardiovascular fitness, but muscle strength was only improved in the resistance group. These different types of exercise showed different patterns of improvement but all three increased distance travelled in the 6MWT. These findings suggest that different targeted exercise can show differing improvements in outcome measures and in turn participants' physical ability.

Cruise, Bucks, Loftus, Newton, Peforaro and Thomas (2010) compared a twelve week exercise intervention with a non-active PD control group. The exercise group completed both cardiovascular and strength exercises twice weekly as part of the intervention. Mood, quality of life and cognition were explored pre to post assessment. Results suggested there were significant improvements in executive function. No change in mood and quality of life were observed following the exercise sessions. This research suggests that exercise on its own does not lead to improvements in mood and quality of life. This differs to study one that suggested that dance had a significant effect on mood. These differences could be accounted for through the social and music aspects of the dance sessions measured in study one, that were not included in Cruise et al. (2010).

It has also been suggested that dance and exercise through virtual reality can be beneficial for those with PD. Previous research has found that a virtual reality dance game (using the Wii Fit balance board) leads to an improvement in physical symptoms in PD (Esculier et al. 2012). Lee, Lee and Song (2013) investigated virtual dance on a number of outcome measures. There were both an experimental and control group,. the experimental group was made up of participants completing the Dance Along virtual reality for 30minutes, five days a week for six weeks. The participants completed the game on their own with the game interface. This in effect makes this a solo dance session. Participants were found to have significant improvements in balance, activities of daily living and

depression. This may suggest that improvements can be seen in these outcome measures without the social aspect of a dance class. There is however an argument that the game in itself has a social interface.

Mood has also been been shown to significantly improve following virtual reality exercise. Plante, Aldridge, Bogden and Hanelin (2003) investigated this in the general population. Eighty eight participants completed 30 minutes of activity, split into three groups. Groups were:

- Those exercising on a stationary bicycle
- Those using a virtual reality bicycle game
- Participants using a virtual reality bicycle game whilst cycling on the stationary bicycle.

Participants were measured on three scales, pre and post intervention. These included a mood scale, social desirability scale and perceived exertion scale. Results suggested that both the exercise groups (with and without the virtual reality) had decreased levels of tension and increased energy and relaxation compared to the virtual reality only group. The virtual reality and exercise condition showed the greatest improvements with significantly less tiredness, and higher levels of relaxation, exertion and enjoyment. These studies into virtual reality have shown that a number of outcome measures can be improved whilst using virtual reality software and exercise in partnership. A key point here is that these virtual reality exercise and dance games do not involve the social impact of an exercise or dance class, and may give an indication that participants may not need the social impact of class to have improvements in both physical and psychological improvements.

There have however, been studies to suggest that the link between mood and exercise is not as clear-cut. Lennox, Bedell & Stone (1990) found no change in mood following exercise in a non clinical sample. Steptoe & Cox (1988) also failed to show any significant changes in mood following high and low intensity exercise, one session with music and the other with a metronome tick. This study did find that there was a significant improvements in mood in the low intensity

group that was not seen in the high intensity group, suggesting that level of intensity has a bearing on mood changes following exercise. This study would suggest that lower intensity exercise is more beneficial for mood improvements than high intensity training. This study suggests that music may not have an effect on mood following exercise and in order to illicit mood changes, lower intensity exercise is required. These studies however, focus on exercise rather than dance. There are a number of components of dance that are different to exercise, such as the effect of music and rhythm and the social aspect of the activity.

Very few studies have investigated the role of exercise on mood for those with PD, these also tend to focus on change in depressive symptoms rather than positive affect. A number of meta-analyses have investigated the effect of exercise in PD, but focus on physical outcome measures. Both Crizzle & Newhouse (2006) and Goodwin et al. (2008) conducted a meta-analyses of exercise in those with PD. Both found significant improvements in physical measures. For Goodwin et al., four studies were included that suggested significant improvements in quality of life following exercise. Cruise, Bucks, Loftus, Newton, Pegoraro & Thomas (2011) investigated cognitive function, depressive symptoms and quality of life in PD following a 12 week exercise (aerobic and strength) intervention. No changes were observed for quality of life or depressive symptoms after the 12 weeks.

Schmitz-Hübsch, Pyfer, Kielwein, Fimmers, Klockgether & Wüllner (2006) investigated Qigong exercise on the symptoms of PD. This form of exercise differs from many of the previous exercise that have tended to use more traditional exercises such as aerobic or strength training exercises. Qigong includes slow graceful movements that focus on breathing and relaxation. Schmitz-Hübsch et al. (2006) investigated a number of outcome measures including the UPDRS, PDQ-39, Montgomery-Asperg Depression Rating Scale (MADRS) and structured interview. The sessions were once weekly for 60 minutes. Participants were assessed after three and six months and were taught in two eight week courses, with an eight week break between. Participants also

completed a 12month follow up, six months after completing the intervention. For the physical outcome measures, significant improvements were seen in the UPDRS III at three and six months. No significant change from baseline was observed after 12 months. For quality of life, no changes were seen at any of the time points. Unfortunately, this study failed to report depression outcome data due to inbalances in the depression and control group at baseline. Therefore this study showed that physical changes were observed in this study, but no changes were seen in quality of life and further data were not reported.

The previous literature has suggested that there is very limited evidence exploring the effect of mood in PD following dance and exercise sessions. Research into the general population and the elderly has suggested that there may be immediate changes in mood following exercise. Virtual reality game studies have also suggested that exercise and dance may be a useful tool to improve physical and psychological health without attending a traditional class. These studies may suggest that health benefits for those with PD may be obtained without the social group in their own homes.

The current study aims to investigate whether immediate changes in mood are observed in those with PD when completing a music and movement intervention in their own homes. This study will explore whether a short exercise of 30 minutes in participants own homes can have an effect on mood levels. Previous literature has found that 30 minutes of dance and exercise is long enough to show improvements in mood. Koch, Morlinghaus & Fuchs (2007) explored the effect of 30 minutes of circle dancing on depressed psychiatric patients. This study found that just 30 minutes of dance had a significant positive effect on levels of depression and vitality compared with those exercising on a bike or listening to music. This was also seen in Plante et al. (2003) that found exercising with a virtual reality game for 30 minutes lead to increased enjoyment. These studies would suggest that 30 minutes of activity would be sufficient to have an effect on mood.

7.2 Method

7.2.1 Participants

Participants were 52 people with PD. Participants were predominantly recruited from Parkinson's UK support groups. A brief synopsis of the research was also sent out to the Parkinson's UK research support mailing list. The first stage of recruitment was to contact the leaders of local Parkinson's UK groups and enquire whether it was possible to attend their groups to discuss the research. An information sheet was posted on the Parkinson's UK research support network for the South East. Emails were also sent to previous participants that had indicated they would like to be contacted for future research. As the researcher travelled to participants homes to conduct this research, participants were recruited from within a one and a half hour driving radius of the University of Hertfordshire.

7.2.2 Measures

Participants first completed a number of demographic questions, this included information such as length of time with disease and current medication taken, this was followed by the Hoehn and Yahr scale (Hoehn & Yahr, 1967) to assess disease severity. The researcher completed these questionnaires, with information obtained from participants. The Dependent variable was a mood questionnaire, which was assessed by the BRUMS (Terry & Lane, 1993).

7.2.3 Design

The current study is a 1X1within subject design, with one independent variable; time, with two levels (pre and post assessment).The dependent variable is mood (BRUMS)

7.2.4 Hypotheses

- Mood will significantly improve immediately following an exercise to music session

7.2.5 Procedures

Participants were recruited through local Parkinson's UK support groups and individuals that had expressed interest in completing research in the past. The researcher visited participants homes in order to complete the research. After signing the consent form, participants were asked some standard demographic questions, as well as PD specific information. Participants were then given the Hoehn & Yahr (1967) scale as a measure of disease severity. This was followed with the BRUMS questionnaire. Once these questionnaires were completed, participants took part in a 30 minute movement to music DVD, this included exercises recommended by Parkinson's UK and falls prevention classes. These were completed in a seated position to music. Following the DVD, participants were again given the BRUMS mood questionnaire and debriefed appropriately.

7.2.6 Statistical analyses

In order to determine whether there is a relationship between the different variables, data were analysed using both repeated measures ANOVA and MANOVA. MANOVA was conducted on dependent variables that were theoretically grouped (BRUMS). ANOVA was conducted on the dependent variables that did not group (BRUMS TMD). MANOVA is used in order to protect against type 1 errors, multiple repeated measures ANOVA would inflate this. Assumptions of these statistical tests can be seen in appendix C.

7.2.7 Ethics

Ethical approval was obtained from the School of Psychology Ethics Committee at the University of Hertfordshire. Protocol Number: **LMS/PG/UH/00317.**

7.3 Results

Participants were 52 people with PD. Two participants were removed from the statistical analysis, one participant suffered with Dementia and the other required assistance to complete the DVD and was unable to complete the DVD. For the remaining 50 participants, 26 were male, 24 female diagnosed with PD. Each participant rated themselves for disease severity, with participants ranging

from I to III on the Hoehn & Yahr scale (Hoehn & Yahr, 1967). Participant's demographic information can be seen in Table 7.1.

Table 7.1. Demographic information

	Male (N=26) M (SD)	Female (N=24) M (SD)	Total group (N=50) M (SD)
Age	70.12 (6.199)	67.38 (8.57	68.80 (7.48)
Hoehn & Yahr	2.10 (.76)	1.81 (.66)	1.96 (.72)
Age diagnosed with PD	61.92 (8.77)	59.33 (9.89)	60.68 (9.32)
Years with PD	8.19 (5.95)	8.04 (6.09)	8.12 (5.96)

Table 7.1. Indicates little difference between male and female participants in the current study. There were no significant differences between genders for the above demographics (*p*>.05). Participants were in the mild to moderate PD bracket as measured by the Hoehn & Yahr scale, the mean of 1.96 suggesting that participants were moderately affected by the symptoms of PD. Participants had on average suffered with the disease for eight years, although there was a large range in the data of between one and 27 years.

All participants with the exception on two were taking medication for their PD symptoms. Table 7.2. Shows the variety of medications being taken by participants.

Table 7.2. Medication taken by participants

Medication	Frequency
Levodopa only	7
Dopamine Agonist only	3
Levodopa and Dopamine Agonist	16
Levodopa and MAO B inhibitor	9
Levodopa, Dopamine Agonist and MAO B inhibitor	7
Dopamine Agonist, Levodopa, MAO B inhibitor and Glutamate Agonist	3
COMT inhibitor, Dopamine Agonist and Levodopa	1
MAO B inhibitor	1
Dopamine Agonist , Levodopa and Glutamate Agonist	1

*MAO B = Selective Monoamine Oxidase inhibitors *COMT = Catecholomethyl Transferase inhibitors

Medication levels in the current study are in line with expectations, with Levodopa, Dopamine Agonists and a combination of the two being the most popularly prescribed drugs. It is worth noting that Dopamine Agonists are well documented to have some cognitive side effects such as hallucinations, delusions and confusion which could have an effect on mood and quality of life outcome measures. These type of cognitive side effects are not seen in the other medications participants in this study were receiving.   No participants were receiving Anticholinergics for the disease. Nine of the participants were also taking an antidepressant alongside their medication. These were generally prescribed for other reasons such as excess saliva and pain.

Table 7.3. Mean scores for BRUMS pre and post

	BRUMS pre M (SD)	BRUMS post M (SD)
Tension-Anxiety	2.46 (2.48)	.917 (1.82)**
Depression-Dejection	1.31 (2.0)	.479 (1.11)*
Anger-Hostility	.56 (1.29)	.21 (.97)*
Vigor-Activity	6.88 (3.22)	7.69 (4.0)*
Fatigue- Inertia	3.29 (2.81)	3.35 (3.11)
Confusion - Bewilderment	1.75 (2.13)	1.0 (1.83)*

A higher score indicates a higher level of that dimension, i.e. a higher Depression-Dejection score would indicate participants feel more depressed. ** $p<.001$, * $p<.05$.

Two of the 50 participants in the model had one piece of missing data and were therefore not included in the MANOVA Model. A repeated measures MANOVA on the BRUMS dimensions revealed a significant improvement, $F(6,42) =3.98$, $p=.003$, $n\text{p}^2=.36$ for the model. This suggests that overall the dimensions of mood tested post task, showed an improvement from pre testing.

Follow up Univariate ANOVA's suggested that five out of the six of the dimensions improved over time. For tension-anxiety, there was a significant decrease in feelings of tension-anxiety over time, $F(1,47) = 23.12$, $p<.001$, $n\text{p}^2=.33$. For depression-dejection, there was a significant decrease in feelings of depression over time, $F(1,47) = 8.67$, $p=.005$, $n\text{p}^2=.17$. For anger-hostility, there was a significant decrease in feelings of anger over time, $F(1,47) = 6.584$, $p=.014$, $n\text{p}^2=.12$. Feelings of vigor-activity also improved over time, $F(1,47) = 4.12$, $p=.048$, $n\text{p}^2=.08$. Levels of confusion-bewilderment also decreased over time, $F(1,47) = 8.75$, $p=.005$, $n\text{p}^2=.16$. Fatigue-inertia showed no change over time, $F(1,47) = .019$, $p=.89$. This suggests that there were positive changes in mood for feelings of tension-anxiety, depression-dejection, anger-hostility, vigor-activity and confusion-bewilderment. There were no changes in the levels of fatigue-inertia that participants were feeling from pre to post interaction with the DVD.

BRUMS TMD was analysed using Repeated measures ANOVA between pre and post assessments. The Repeated measures ANOVA revealed a significant improvement between time points, $F(1,47) =12.42$, $p=.001$, $n\text{p}^2=.21$. This suggests that there was an overall improvement in mood after completing the music and movement DVD.

Due to nine participants taking antidepressants, line graphs were created in order to assess whether those taking this medication differed on their mood scores pre and post DVD.
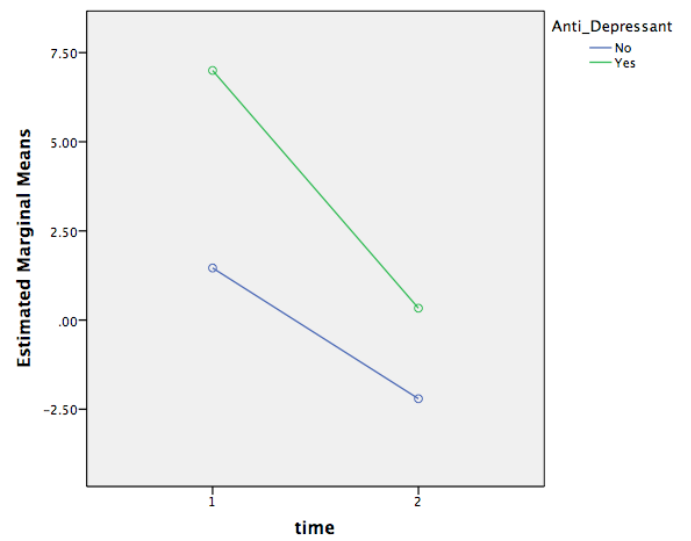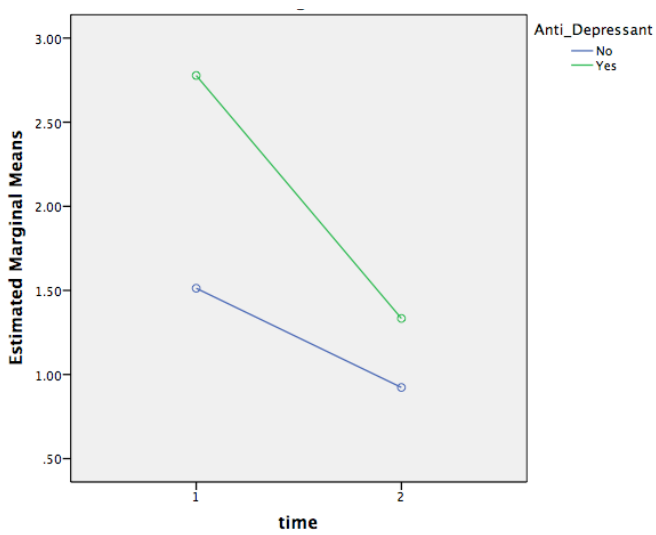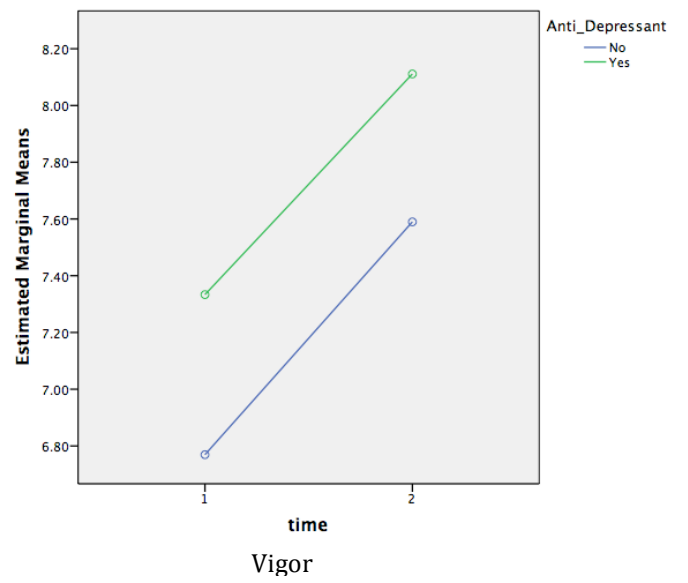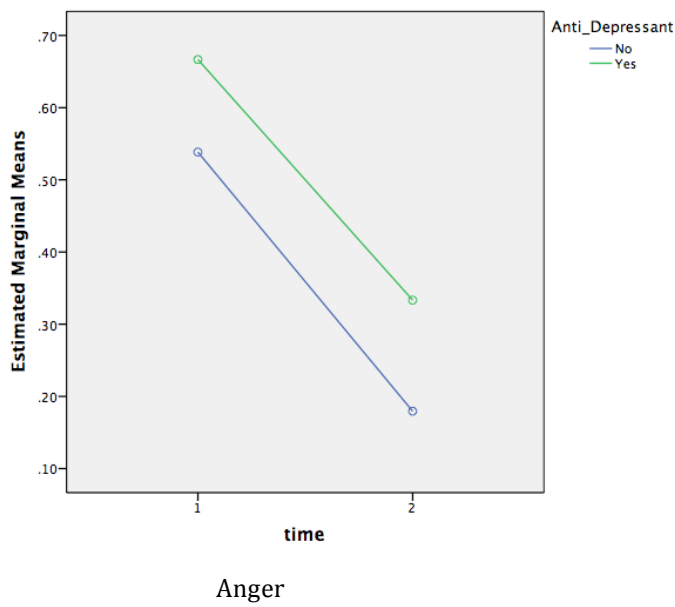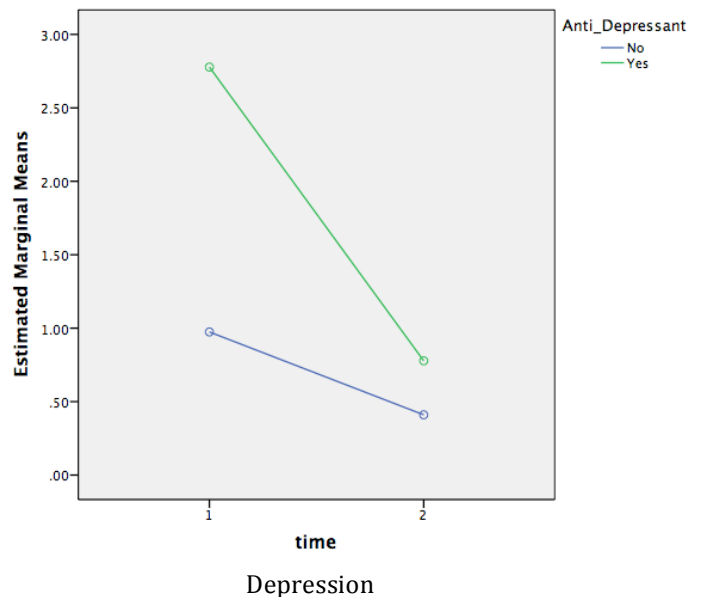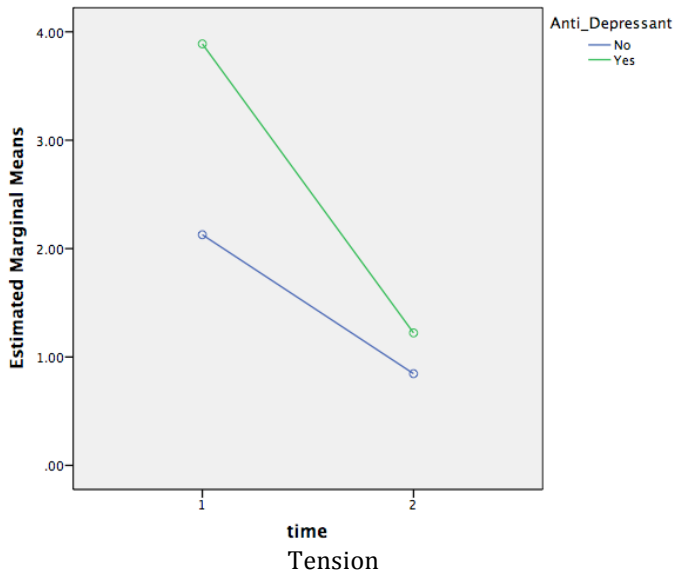
Tension

Depression

Anger

Vigor

Figure 7.1. Line graphs for significant dimension of BRUMS and BRUMS TMD

Figure 7.1 shows the mood scores of participants with and without antidepressant medication. These graphs show that both groups tend to have the same pattern of change between pre and post assessments. In all cases, those taking antidepressants tended to have a higher pre score than those that did not. These however, did not significantly differ at pre testing for all the dimensions and TMD (p>.05) except for the depression dimension t(48) = -2.13, p=.038. Those taking antidepressants showed significantly higher pre depression-dejection scores than those not taking antidepressants.

7.3.1 Removal of those taking antidepressants

Analysis of 39 participants that were not taking antidepressants were included in this post hoc testing. A repeated measures MANOVA on the BRUMS dimensions revealed a significant improvement, F(6,33) =2.88, p=.023, np^2=.34 for the model. This suggests that overall the dimensions of mood improved when those taking antidepressants had been removed from the data and when they remained in the analysis.

Follow up Univariate ANOVA's for tension-anxiety, anger-hostility and confusion-bewilderment showed significant improvements over time. This was not the case for depression-dejection, vigor-activty and fatigue-inertia. For tension-anxiety, there was a significant decrease in feelings of tension-anxiety over time, F(1,38) = 14.86, p<.001, np^2=.28. For anger-hostility, there was a significant decrease in feelings of anger-hostility over time, F(1,38) = 5.46, p=.025, np^2=.13. Levels of confusion-bewilderment also decreased over time, F(1,38) = 5.08, p=.03, np^2=.12. For depression-dejection, there was a borderline significant decrease in feelings of depression over time, F(1,38) = 3.28, p=.078, np^2=.08. Feelings of vigor-activity also showed a borderline significant change over time, F(1,38) = 3.31, p=.077, np^2=.08. Fatigue-inertia showed no change over time, F(1,38) = .01, p=.92. This suggests that there were positive changes in mood for feelings of tension-anxiety, anger-hostility and confusion-bewilderment. There were changes approaching significance for anger-hostility and vigor-activity. Therefore, removing those participants taking antidepressants did change the results in terms of removing significant changes

for anger and vigor. There were no changes in the levels of fatigue-inertia, this was not affected by those taking antidepressants.

BRUMS TMD was analysed using Repeated measures ANOVA between pre and post assessments. The Repeated measures ANOVA revealed a significant improvement between time points, $F(1,38) =6.56$, $p=.015$, $n\text{p}^2=.15$. This suggests that there was an overall improvement in mood irrespective of whether participants were taking anti-depressants.

When comparing pre and post scores for depression using an independent samples t test, it became clear that those taking antidepressants were significantly more depressed at pre testing than those not taking anti depressants, $t(48) = -2.13$, $p=.038$.

Following the previous analysis, MANCOVA (POMS dimensions) and ANCOVA were conducted with the covariate of medication. Both ANCOVA and MANCOVA showed no significant changes from pre to post assessment when the covariate of medication was added, $p>.05$.

7.4 Discussion

The main findings of the study were that participants showed a significant immediate improvement in mood following a music and movement activity. For all dimensions of mood except for fatigue-inertia, participants had lower levels of tension-anxiety, depression, anger-hostility and confusion-bewilderment following the intervention. Participants also felt more vigorous. The study also found that overall mood (as measured by BRUMS TMD) improved over time. This pattern of results is to be expected after physical activity and was also seen in Lane & Lovejoy (2001). This pattern of results with no change in fatigue-inertia and significant improvements in all other dimensions is identical to that of Lane and Lovejoy (2001) following dance.

After removing participants that had reported taking anti depressants (regardless of reason for taking), a similar pattern of results was seen. There was

a main effect of the BRUMS total mood disturbance score. Significant improvements also remained for tension-anxiety, anger-hostility and confusion-bewilderment. Both vigor-activity and depression-dejection became non significant with the exclusion of those participants taking antidepressants. Fatigue-inertia remained the same in both cases. For the dimension depression-dejection, no significant change was observed from pre to post assessment, there was however, a borderline significant result. There was also a significant difference between pre scores for the dimension depression-dejection. This suggests that participants taking antidepressants were significantly more depressed than those without anti-depressants.

In order to attempt to statistically control for the confound of medication, ANCOVA and MANCOVA were run for all outcome measures. No significant differences were observed for BRUMS dimensions or BRUMS TMD following this analysis. This may suggest that differences from pre to post assessment may have been affected by medication and when this was controlled for, these improvements did not hold up. This analysis however, has its own limitations and are discussed in section 10.7.

Interestingly when removing the anti-depressant group, overall change in feelings of depression-dejection went from significantly improved to borderline significant improvement. This may suggest that those with higher pre depression scores benefitted more from the exercise, than those with a lower pre score. This fits with previous research that suggested that those with depression benefit more greatly from completing exercise on mood dimensions (Lane & Lovejoy, 2001).

These findings are in line with previous research that suggested mood improvements following exercise and dance (Lane & Lovejoy) can be seen immediately after a session. This is important for those with PD that have been shown to have a greater instance of depression and anxiety than the general population (Slaughter, Slaughter, Nichols, Holmes & Martens, 1999). Slaughter et al. suggested that around 45% of those with PD have symptoms of depression,

that has been suggested to be linked with the deterioration of dopamine and noradrenaline in the limbic system in those with PD (Remy, Doder, Lees, Turjanski & Brooks, 2005). This high prevalence of depression makes it important to create interventions for people to improve mood in a safe way. The current study has demonstrated that music and movement in their own home can have a positive mood improvement.

One factor that could have played a part in the current research is demand characteristics. Participants were aware they were completing a mood questionnaire before and after the intervention. It may be the case that participants may have unintentionally completed the mood questionnaire with this in mind. A number of participants discussed their joy at research being conducted into PD and were very enthusiastic about taking part. An example email is shown below:

> *'THANK YOU SO MUCH FOR YOUR INTEREST IN PARKINSONS IT LIFTS MY SPIRITS'*
>
> Participant 115

This response was indicative of participants and many expressed this in conversation with the researcher. With the outcome measure in the current study being mood changes, this factor may have unknowingly contributed to positive changes following the DVD. A number of participants were keen to discuss their personal experiences of PD with the researcher and often stated that they enjoyed talking to someone about their condition.

Participants completed the DVD in their own homes without the social context of a group class. Although there was no social input of other people completing the same movements, the researcher did complete the assessments before and after the DVD. Although the current study was aiming to investigate the role of music and movement on mood, there was a confounding variable of the researcher. The researcher was present both before and after the DVD was completed to complete the required questionnaires. This may have had an implication for the

social interaction of participants. Both before and after the DVD, participants were keen to talk about their condition and experiences. This in itself was a social experience for participants, and a number described looking forward to the 'event'. This may suggest that findings were confounded by the social interaction of the researcher, rather than completing the music and movement task.

These findings may suggest that those with PD can benefit from participating in exercise, even without the group setting. This has implications for those unable to attend local groups, such as those with more advanced symptoms or in more rural areas that have less on offer for those with PD. This study is the first to investigate the effect of this type of intervention on mood. The study has found that people with PD can have increased mood in their own home after completing a music and movement DVD.

In terms of the programme of research, this study again shows that mood can be improved immediately after an intervention. This study used a music and movement DVD to explore changes in mood. These improvements in mood, compare with study one that found immediate improvements following dance. This study shows that in two short term studies, music and movement can bring about mood improvements. This study was completed without the social interaction of a group. There was however the researcher present during the assessments, which may have a social impact on the research. The next step of this research is to investigate whether mood improvements can be seen using the same music and movement DVD, but without the researcher present.

Chapter 8: The effect of music and movement on physical and psychological outcome measures in PD

8.1 Introduction

The purpose of the study was to investigate whether listening to music alone, music coupled with movement or movement only has an effect on physical and psychological measures in people with PD without the presence of the researcher. As described below, findings from study one showed that dance can improve mood, quality of life and some physical symptoms. It is not clear whether the movement is key to the improvements that have been observed following dance and exercise, or whether listening and moving to the music may be a factor.

Findings from study two suggested that in a real world situation, those completing dance had no differences in mood from those completing exercise, other social activities or no social activities.

Study three investigated immediate short term changes in mood following a music and movement DVD. This study found significant effects of total mood score (BRUMS TMD), and all the dimensions of BRUMS except fatigue-inertia. These findings suggested that immediate changes in mood can be obtained without the social impact of a dance class and can be used in peoples own homes. One limitation of this study was that the researcher was present during the assessments which may have had a confounding effect on the non social aspect of the research.

Completing a dance class has a number of properties such as the social interaction of being with a group, moving your body in a way which may be unfamiliar to you, completing a cognitively demanding task (learning and remembering specific movements) and following a beat.   This study aims to isolate the role of music and movement separately from dance and the social elements of group dance. This study will further explore the findings of study

three and will investigate whether changes in mood are still observed when the researcher is not present for assessments.

8.1.1 Previous Literature

Previous research has mainly focused on the effect of music on walking and motor symptoms of PD (Hayashi, Nagaoka and Mizuno, 2006; deBruin, Doan, Turnbull, Suchowersky, Bonfield, Hu, & Brown, 2010). Within this area there have been mixed findings, with a number of papers suggesting that moving to music may be beneficial for those with PD (De Bruin, 2010) and some that suggest music may actually be an unwelcome distraction (Brown, 2009). The majority of research investigating the role of music on movement in rehabilitation have used Rhythmic Auditory Stimulation (RAS). RAS is the use of a strong rhythmic beat to help train and improve rhythmic movements in the body, most commonly gait. The beat can be alone, such as the use of metronome or drum, or it can be embedded within music.

The main body of research using music to improve physical symptoms has focused on walking and gait. Hayashi et al. (2006) investigated the effect of music on a number of walking parameters in those with PD. Hayashi et al. (2006) identified that just listening to Rhythmic Auditory Stimulation (RAS) embedded within music for one hour a day for three to four weeks produced improvements in walking. Gait speed and stride length significantly improved ($p<.001$) after the activity. Interestingly, it was also found that levels of depression-dejection were also significantly improved ($p>.05$) after listening to music. This suggests that moving to music can improve mood and feelings of depression, and overall walking speed. The researchers concluded that this may be due to the external rhythmic cue of the music replicating the natural rhythm for movement that those with PD have lost.

Thaut and colleagues have consistently identified improvements in gait in both participants following a stroke (Thaut, Kenyon, Schauer & McIntosh, 1999) and those with PD (Thaut, McIntosh, Rice, Miller, Rathbun & Brault, 1996; McIntosh, Brown, Rice & Thaut, 1997) using RAS. McIntosh et al. (1997) found that those

with PD were able to modify their stride length and pattern, to match a beat. This was observed when participants were both 'On' medication, but also when they were taken off. Improved gait, stride length and cadence were also seen after three weeks RAS home based training. This involved walking to rhythmically accentuated instrumental music with increasing tempo over the three weeks.

Music has also been seen to show improvements in a reaching task. Sacrey, Clark and Wishaw (2009) compared those with mild PD (Hoehn & Yahr score of less than 2.5) with more severe participants (Hoehn & Yahr score above 2.5) on a reaching task. The task involved reaching food from a seated position and bringing it to their mouths. Fourteen participants completed three conditions, skilled reaching with eye tracking, skilled reaching with visual occlusion (such that the participant could not see the object) and skilled reaching with music. For the skilled reaching, participants performed the task with no visual restriction. For the visual occlusion task, participants were required to complete the task whilst wearing opaque goggles, occluding both central and peripheral vision. The music task (skilled reaching with music) included participants reaching for the food item whilst listening to music through headphones. Before the study, participants chose two songs from their favourite artists to complete the task to. The music had not been modified to include rhythmic auditory stimulation. Participants with PD were compared with both elderly controls and young adult controls. For those with PD, findings suggested that the music did not improve reaching ability, however those with more severe PD showed improvements in visual engagement with the object, making them similar to the mild PD and control groups. Although no physical changes were observed for the music condition, this may have been due to participants only listening to music for two songs or perhaps that there was no RAS embedded within the music (Sacrey et al, 2009).

Aspects of motor coordination have also been shown to have improvements in those with PD after listening to music (Bernatzky, Bernatzky, Hesse, Staffen & Ladurner, 2004). Bernatzky et al. (2004) investigated the effect of short term

156

music exposure on motor coordination in those with PD and healthy elderly controls. Aiming and line tracking subtests of motor co-ordination showed improvements after listening to self selected, non rhythmic, drumming music for 20minutes. Aiming refers to small target movements that require hand eye coordination in which participants tapped 20 circles as quickly as possible with a stylus, without a hand touching the base plate. Line tracking refers to hand and arm co-ordination, this task required participants to trace a grooved line with a styles, without the hand touching the base plate. No significant changes were observed for steadiness, tapping, and frequency of taps on a forceplate. This suggests that the precision on movement was affected by the music, but not the speed. This shows that music may have an effect on some motor symptoms, however this may be in only certain aspects of coordination.

However, not all previous research has shown a benefit of music on physical symptoms in PD. Brown, DeBruin, Doan, Suchowersky and Hu (2009) suggested that music negatively affected gait. Participants completed four tasks, walking 10 metres with either no music accompaniment or cognitive task, music with no task, no music but with a cognitive task and both music and a cognitive task. Motion capture analysis was used to assess a range of characteristics within a participant's gait. Results found that listening to music whilst walking negatively affected the participants gait patterns, this was further impaired when completing the music and cognitive task condition.

Listening to music alone has been shown to increase positive affect (McDermott et al. 2005) and decrease levels of depression and confusion (Sarkamo et al. , 2008) in a range of conditions, such as those recovering from a stroke. Both Sarkamo et al. (2008) and Sarkamo and Soto (2012) suggested that listening to music daily had an impact on a number of outcome measures following a stroke. Both studies found improvements in mood over and above control groups as well as improved verbal memory and focused attention. Rigg (1964) suggested that tempo was the most important feature in determining mood levels. Those with PD are known to have a deficit in dopamine levels (Lotharius, and Brundin, 2002) which has been implicated in changes in mood levels (Ashby, Isen and Turken, 1999). Ashby et al. (1999) describe the dopaminergic theory of positive

affect. This suggests that the event causing the increased mood stimulates the substantia nigra (and in turn releases dopamine), which also leads to an increase in motor activity. This may suggest that an increase in mood may have symptomatic implications for those with PD. Animal studies have also shown that listening to music can increase dopaminergic transmission and dopamine concentrations (Sutoo, 2004). Therefore, there seems to be a link with music increasing mood, which may stimulate dopamine production and motor movement, therefore indirectly affecting movement.

The effect of music and movement over a 13-week period has also been investigated in those with PD (DeBruin et al., 2010). A music group were assessed on gait parameters both pre and post intervention. These participants walked with a playlist of cadence-matched music, three times weekly for 13 weeks. The control group did not complete any intervention. Those in the music group showed improved gait after the intervention. This suggests that music and movement can be beneficial for walking, however as the control group did not do any activity, it could simply be that the movement improved participants gait, rather than the walking/music combination.

Koch, Morlinghaus and Fuchs (2007) compared effects of music, dance and exercise only on those with diagnosed depression. Participants completed between 20 and 30 minutes of either a group dance session, group music session or group exercise session, which involved riding a static exercise bike. Results suggested that dance may improve levels of depression and vitality over that of music and movement only. Although, this study was only a short 20-30 minute intervention there were mean changes in depression of up to 1.6 points on a 10 point scale, suggesting that a longer intervention would be beneficial to discover whether these effects are greater over a prolonged period. In terms of mean scores, the music group reported lower levels of depression and higher vitality and affect than both the dance and home trainer groups. In terms of mood, the music group started with a higher, pre testing mean score than both other groups. Whether differences were statistically significant between groups, was not reported; however it may have had a bearing on results. The results from

this study showed that that dance may be more beneficial as a short term intervention than exercise and music only.

The findings suggest that those with higher levels of depression may benefit more from this type of intervention than those with lower levels of depression, see table 8.1. Approximately 45% of people with PD have depression (Matthias et al., 2004) indicating that these types of intervention may be relevant to those with PD.

Table 8.1. Mean's for Koch et al. (2007)

Condition		N	M Pre-test	M Post Test
Depression	Dance	11	4.82	3.59*
	Music	10	3.75	4.00
	Exercise bike	10	4.55	4.60
Vitality	Dance	11	4.18	5.82*
	Music	10	5.60	5.95
	Exercise bike	10	4.75	5.35
Affect	Dance	11	5.59	5.82
	Music	10	6.15	6.75
	Exercise bike	10	5.10	5.80

For depression, lower post test scores represent improvement. For vitality and affect, higher post test scores represent improvement

Another study that compared dance, music and exercise was conducted by Campion and Levita (2012). Healthy adult participants completed either dancing, cycling, listening to music or sitting quietly for five minutes with assessments before and after. The assessments measured mood, verbal and non verbal creativity and heart rate. In terms of mood, both dance and listening to music passively showed a significant improvement in emotional wellbeing, decrease in negative affect and increase in positive affect. Cycling had a significant improvement in positive affect but not other mood measures. The quiet control condition had no effect on any mood variables. Non verbal fluency was increased in the music, exercise and quiet group but not in the dance group.

Non-verbal originality was increased in the music condition. This study suggests that dance and music listening has the most effect on mood, although exercise did improve negative mood. There were some changes in creativity, notably for the exercise group that increased in verbal fluency and non verbal originality.

The current study aims to analyse whether music alone or with movement is more beneficial for those with PD. Study four will determine whether listening to music for 30 minutes per day, completing basic exercise or moving to music, does in fact improve mood levels, and whether mood levels have an effect on perceived severity of symptoms. Participants will complete three tasks, listening to music, completing exercises and completing the exercises to music. The POMS mood scale will be administered before and after participants completed each task. There is reason to suggest that listening to music alone may be able to improve mood and movement (Hayashi et al., 2006; Bernatzky. Bernatzky, Hesse, Staffen, & Ladurner, 2004). For physical symptoms, the majority of the previous research focused on using RAS within music in order to show improvements in gait. As this study is not focusing on gait and walking movements, the music participants listen to will not include RAS, but has been chosen as it had a strong upbeat tempo of 120bpm (Hayashi et al., 2006). The current study will focus on self reported assessment of a range on PD symptoms within the MDS-UPDRS.

8.2 Method
8.2.1 Participants
Participants were 24 people with PD, with each participant completing all three conditions (music only, movement only and movement and music together). Participants were 16 females and 8 males (N=24) diagnosed with PD. Each participant rated themselves for disease severity, with participants ranging from I to III on the Hoehn & Yahr scale (Hoehn & Yahr, 1967). Participants were recruited by visiting Parkinson's UK support groups as well as contacting individuals on our database that have indicated that they would be interested in participating in future research. The first stage of recruitment was to contact the leaders of local Parkinson's UK groups and enquire whether it was possible to

attend their groups to discuss the research. An information sheet was posted on the Parkinson's UK research support network for the South East. Emails were also sent to previous participants that had indicated they would like to be contacted for future research; four participants from the current study had completed part in previous studies within this programme of research. As the initial assessment required a face-to-face meeting, participants were recruited for a one and a half, to two-hour driving radius of the University of Hertfordshire.

8.2.2 Measures

Participants completed the Hoehn and Yahr scale (Hoehn & Yahr, 1967) followed by the DVs. Firstly, the MDS-UPDRS self report sections I and II (Goetz et al. , 2008). This measures participant's abilities to complete both motor and non-motor aspects of daily life. Participants also completed the PDQ-39 (Peto et al., 1995) and mood measured by the POMS (McNair et al. , 1971). Details of these measures can be found in Chapter 3.

8.2.3 Design

This study was a 3X2 within subjects design with two independent variables: Group, with three levels (music, movement and music and movement) and time with two levels (pre and post assessment). The dependent variables were POMS scores; PDQ-39 scores and MDS-UPDRS scores. Participants completed all three tasks, with breaks in between each activity. Assessments were given pre and post each activity. Participants were counterbalanced for the order in which they completed the activities.

Table.8.2. Testing schedule

T^1	Testing 14 days	T^2	7days	T^3	Testing 14 days	T^4	7days	T^5	Testing 14 days	T^6
Assess	Activity1	Assess	Break	Assess	Activity2	Assess	Break	Assess	Activity3	Assess

Music Group: Participants were given a CD of the music playlist they were required to listen to for 30 minutes per day for 14 days. Participants listened to the music quietly whilst sitting and not completing any other tasks. All music

was around 120bpm as indicated to show improved movement in Hayashi et al. (2006). Music was from a range of genres, with an upbeat tempo. A list of the music used in this study can be found in appendix E.

Movement Group: Again this task was completed for 30 minutes per day for 14 days. The participants completed a movement programme, completed in the seated position. This intervention was given to participants through DVD instruction. All movement was devised by existing movement programmes, Parkinson's UK keep moving (designed to keep people with PD exercising in their own homes) and OTAGO falls prevention sessions. Exercises included toe taps, seated marching and coordination exercises with a stress ball.

Music and Movement group: Participants completed the same movement task to music. Participants completed the exercise DVD to the music used in the music only condition. Within this condition the movements were set to the beat of the music.

8.2.4 Hypotheses
- Mood will be significantly higher in those completing exercise to music compared to those in the other two conditions following the intervention.
- Those completing exercise will have significantly higher mood than those just listening to music

8.2.5 Procedures
Participants attended the University of Hertfordshire for an initial assessment before starting the experiment, for those unable to travel, the experimenter conducted the assessment in their own home. After reading the information sheet and completing the consent form participants were assessed on the dependent variables. Following this assessment participants were told which intervention they would complete first. Participants were given the chance to watch the DVD and discuss their feelings around the movements and their abilities (all movements can be conducted seated or stood with support). Participants were then given all resources they require (DVD and questionnaire

162

booklet) to complete the study at home. The three conditions were music only, movement only, and music and movement together. Each participant completed all three of these conditions but in different orders. Each condition required participants to complete a task for 30mins per day for 14 days. Participants completed 14 days of their initial condition and then assessed again on the same DVs. There was then a 7 day break where participants did not complete any tasks, followed by another set of assessments. This routine repeated until each participant completed all three conditions. Follow up assessments were conducted either by telephone, email or post depending on the preference of the participant.

As this is an intensive intervention, with a home based intervention, the attrition rate was expected to be higher than the previous two studies. In order to keep as many participants involved as possible, courtesy emails and telephone calls were made to participants regularly.

8.2.6 Statistical analyses

In order to determine whether there was a relationship between the different variables, data were analysed using both repeated measures ANOVA and MANOVA. MANOVA was conducted on dependent variables that were theoretically grouped (MDSUPDRS, PDQ-39 and POMS). ANOVA was conducted on those dependent variables that did not group (PDQ-SI and POMS TMD). Follow up mixed ANOVA and MANOVA's were run for severity of disease (See appendix C for details of statistical assumptions) MANOVA and ANOVA can be quite robust to assumption violations, however as the sample size in the current study is small, adhering to statistical assumptions is vital. In all cases, the above assumptions have been tested, any violations are discussed during statistical reporting.

8.2.7 Ethics

Ethical approval was obtained from the Health and Human Sciences Ethics Committee at the University of Hertfordshire. Registration Protocol Number: **LMS/PG/UH/00017**

8.3 Results

Participants were asked a number of demographic questions before completing the initial assessment. See table.8.3.

Table 8.3. Demographic information

N=24	Minimum	Maximum	M	SD
Age	44	80	64.88	9.05
Hoehn & Yahr	1	3	1.73	.68
Age diagnosed with PD	40	72	59.54	8.98
Years with PD	1	12	5.54	2.86
Physical activity per week (hrs)	0	15	5.96	3.40

Table.8.3. shows that for age there was a large range completing the current study, including early onset PD. Participants were in the mild to moderate PD bracket as measured by the Hoehn & Yahr scale, the mean of 1.73 suggesting that this was towards the more mild end of the disease. Participants also greatly differed in the amount of physical activity they were preforming before the current study began. Participants were not asked to terminate any of their present physical activity.

Participants were all taking medication for their PD symptoms. Table 8.4 shows the variety of medications being taken by participants.

Table 8.4. Medication taken by participants

Medication	Frequency
Levodopa only	4
Dopamine Agonist only	3
Levodopa and Dopamine Agonist	9
Levodopa and MAO B inhibitor	3
Dopamine Agonist and MOA B Inhibitor	1
Dopamine Agonist, Levodopa and MAO B inhibitor	1
Dopamine Agonist, Levodopa, MAO B inhibitor and Glutamate Agonist	1
Levodopa and Glutamate Agonist	1
Dopamine Agonist MAO B Inhibitor and Glutamate Agonist	1

*MAO B = Selective Monoamine Oxidase inhibitors

Medication levels in the current study were in line with previous studies in this programme of research. Levodopa and Dopamine agonists, as expected are the most common type of medication used by participants in this study. No participants were receiving Catecholomethyl Transferase inhibitors (COMT) inhibitors or Anticholinergics for the disease.

Demographics
N=24

Music

Movement

Music and movement

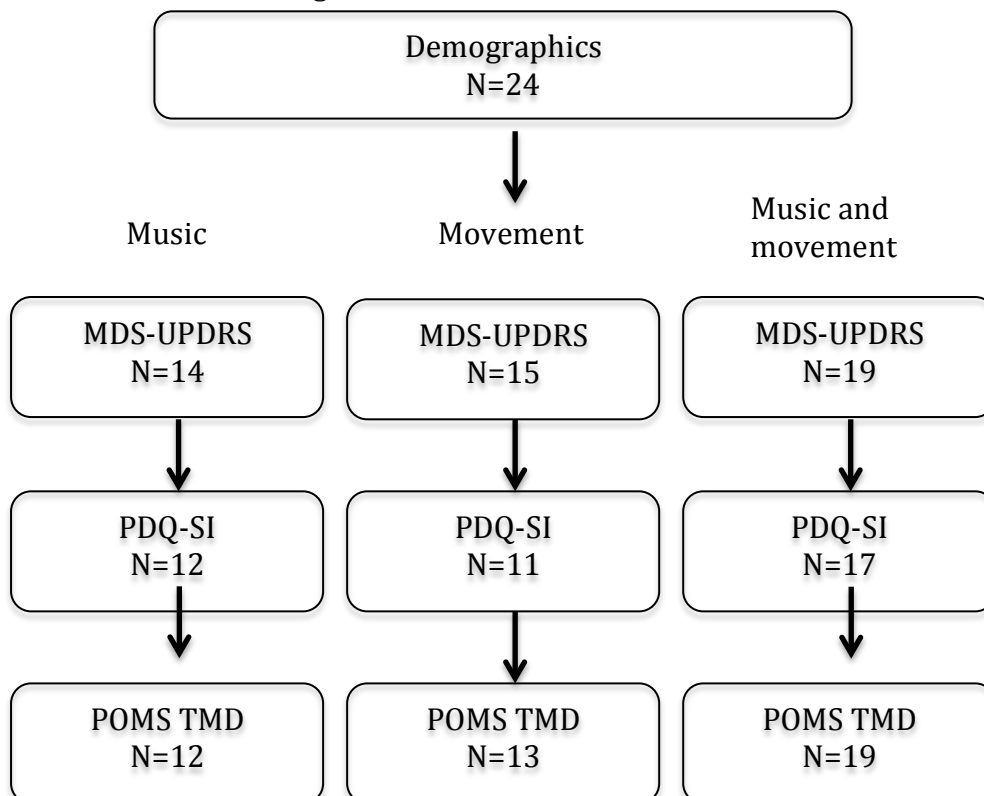| MDS-UPDRS N=14 | MDS-UPDRS N=15 | MDS-UPDRS N=19 |
| PDQ-SI N=12 | PDQ-SI N=11 | PDQ-SI N=17 |
| POMS TMD N=12 | POMS TMD N=13 | POMS TMD N=19 |

Figure 8.1. Participant numbers for each intervention group

Figure 8.1. shows the number of participants in the three conditions. As participants were counterbalanced, the flow chart shows the participants that completed outcome measures and is not representative of time.

For the PDQ-39 SI and POMS TMD, scores are calculated from the dimensions included within the scale. Any missing data means that dimension cannot be scored and therefore the total score cannot be calculated either. In order to be included in the MANOVA, all dimensions are required to be complete.

Pre to post assessments for each outcome measure were conducted. Direct comparisons between conditions (music, movement and music and movement) were unable to be conducted due to low participant numbers.

Music
No significant main effects were reported for PDQ-39, MDS-UPDRS or POMS for the music condition. A measures ANOVA however, revealed a borderline significant improvement between time points for POMS TMD, $F_{(1,12)} =3.695$, $p=.079$. This suggests that there was a trend for overall mood to improve after the music intervention.

Movement
No significant main effects were reported for PDQ-39, MDS-UPDRS or POMS for the music condition, p>.05.

Music and movement
No significant main effects were reported for PDQ-39, MDS-UPDRS or POMS for the music condition, p>.05.

8.3.1 Do the results differ for disease severity?
During this analysis, MANOVA/ ANOVA was run on the data to determine whether disease severity of participants had an effect on the outcome measures. Disease severity was grouped using the Hoehn & Yahr scale (Hoehn & Yahr,

1967). Those with a Hoehn and Yahr score of 1.5 or below, characterised as mildly affected by the symptoms of PD and 2 and above, characterised as moderate PD.

The main effect of severity for MDS UPDRS will not be reported, as the groups differ for severity and therefore will differ on amount of self reported symptoms.

Music

For music there was no main effect of MDS-UPDRS. Repeated measures MANOVA did however find a significant main effect of severity for PDQ-39 SI $F(2,8) =23.916$, $p=.041$, $n\text{p}^2=.990$. There was no main effect of time or interaction, p>.05. When investigating the follow up univariate ANOVA's the dimension 'Activities of daily living' scores differed significantly depending on severity level $F(1,9) =13.961$, $p=.005$, $\text{np}^2= .608$. This suggests the groups scores differed due to their severity. Mild Vs moderate PD differed greatly both at pre and post assessments in Activities of daily living. The dimension has a max score of 100, indicating that those less severe participants had almost no problems with activities of daily living (Mpre=2.976). Those with more moderate symptoms had significantly more problems with activities of daily living (Mpre=29.375).

POMS

Repeated measures ANOVA was conducted to investigate severity on POMS TMD scores. The ANOVA revealed a borderline significant main effect of time $F(1,11) =3.903$, $p=.074$, $n\text{p}^2=.626$. There was no interaction $F(1,11) =.851$, $p=.376$. Figure 8.2. shows the change over time for severity.
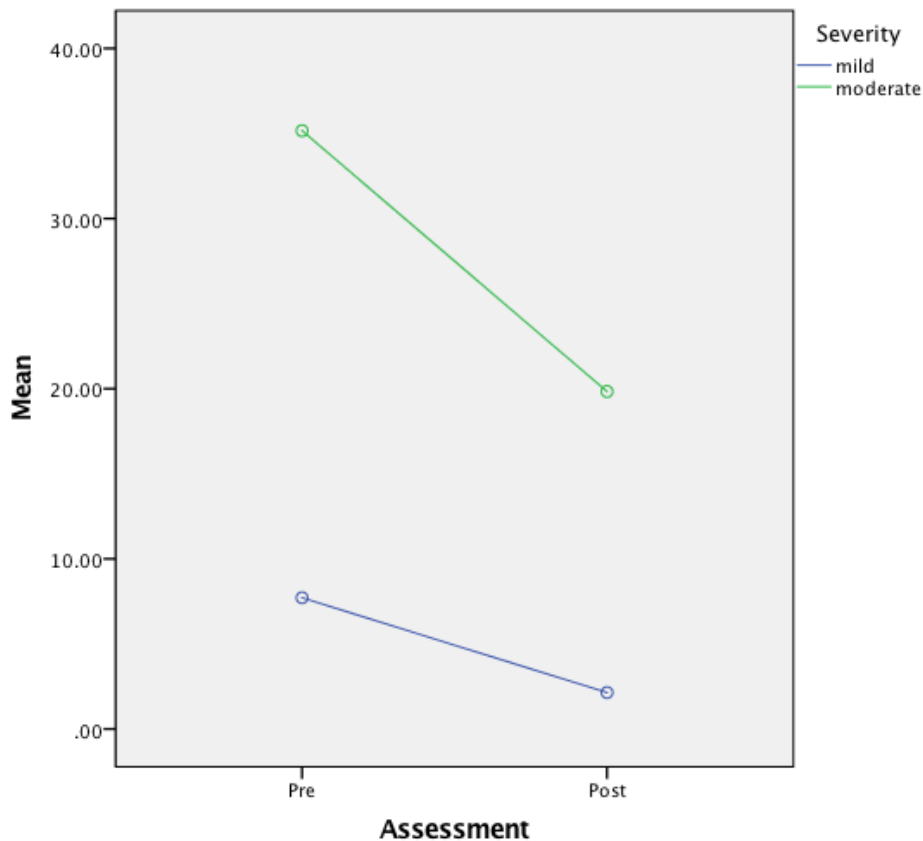
Figure 8.2 POMS TMD changes over time for severity for music.

Even though differences in pre scores for POMS TMD are approaching significance, t(13) =.414, *p*=.066, there is a borderline significant improvement over time in total mood score. This indicates that the music condition could improve overall mood regardless of the severity of pre assessment score. This is in line with the overall borderline significant improvement for POMS TMD scores for music.

The MANOVA revealed no significant main effect of severity, F(6,6) =2.356, *p*=.160, time, F(6,6) =1.276, p=.387 or an interaction F(6,6)=1.778, *p*=.251. This suggests the dimensions were not affected by the intervention.

Movement

No main effects for MDS-UPDRS, PDQ-39 or POMS were reported following the movement condition, p>.05..

<u>Music and Movement</u>

No main effects for MDS-UPDRS, PDQ-39 or POMS were reported following the movement condition, p>.05..

8.3.2 Time one to two intervention effects

In order to investigate whether participants had a change in outcome measures from time 1 to time 2 regardless of the intervention that they completed, paired t tests were conducted for all participants time 1 to time 2 assessments. Paired t tests revealed no significant changes between time points for any of the outcome measures (MDS-UPDRS I, MDS-UPDRS II, PDQ-39 SI, POMS TMD, *p*>.05).

8.4 Discussion

The aim of the current study was to examine whether a home based intervention, independent of social engagement would have an effect on a number of outcome measures. The study aimed to determine whether music, movement, and music and movement together would have an effect on mood, quality of life and self reported PD symptoms.

The main findings of this study showed that there were no significant changes over time for physical symptoms, quality of life and mood for pre and post assessments for each condition (music, movement and music and movement together). For movement, 'activities of daily living' showed a borderline significant improvement between assessments.

For severity, the only significant main effect was observed in the PDQ-39 for the music condition. For the PDQ-39 dimensions for music, there was a significant main effect of group both overall and for ADL. This suggests that scores differed due to level of severity but not the intervention. There are a number of questions within this dimension which would be affected by how severe the disease was such as problems with handwriting or completing household tasks. Therefore, this result would be expected for this measure.

Sacrey et al. (2009) also found differences between severity of participants. Results of this study suggested there were no physical improvements, but did observe improvements in visual engagement with the target object. This may suggest that the physical outcome measures may not be sensitive or accurate enough to observe small changes that may have occurred in the intervention. Sacrey et al. (2009) also only observed these effects in participants with more advanced symptoms of the disease. The current study included 21 out of 24 participants that would have been classified as mild in that study (Hoehn & Yahr <2.5). The MDS-UPDRS 1b and 2 may also not have been sensitive enough in order to detect any changes, specifically if changes were observed in particular domains. The MDSUPDRS 1 and 2 ask global questions including problems with sleep, tremor Bradykinesia etc. In future it would be beneficial to investigate a couple of these symptoms more in depth rather than all symptoms together.

One limitation of the current study is the participant attrition rate. There were a number of participants that dropped out at various stages of the study. This may have been expected due to the intensive nature of the task. Feedback from participants suggested that they felt the task became boring before the two weeks intervention had been completed. Others felt the task took up too much of their time to complete.

Another limitation regarding participants that is worth mentioning is that we don't know how much of the intervention the participants were actually completing. Courtesy phone calls to participants were made and participants assured that they were completing the task. However, it is difficult to tell whether this was in fact the case. An electronic diary to record time stamps of completion of the task would have been beneficial in this study to effectively measure participant adherence. Accelerometers could also be used to track movements throughout the day and would be an indicator to show that participants have completed the task.

Each of the three interventions was run for 14 days, with participants completing their activity for half an hour a day throughout. It is difficult to tell

whether this would have been long enough to see any effects on the outcome measures we investigated. Previous research such as Marchant et al. (2010) and Hackney & Earhart (2009b) have shown significant positive effects of dance after a two week intensive trial in balance, which would suggest that this time frame would be substantial enough to see changes between time points. Mood changes have been seen to change in dance studies almost immediately (Lane, Hewson, Redding & White, 2003). There could have also been carry over effects of the previous task, in future this task would benefit from three separate groups completing the interventions at the same time to eliminate this risk.

One compounding variable of the current may be music preference. The music provided to the participants was a mix of genres and included both old and new music tracks. Feedback from some participants indicated that they did not enjoy some of the music and didn't enjoy listening to the same music every day. This may have had an effect on the mood of these participants, which was one of the key dependent variables. A number of factors have been show to affect music preference, it has been suggested that personality, gender, age and familiarity contribute to a person's appreciation of music (Crowther & Durkin, 1982; LeBlanc, Sims, Siivola, & Obert, 1996, Miranda, Morizot & Gaudreau, 2010; North & Hargreaves, 1995). With such a heterogenous group, it is very difficult to create a playlist that all participants have a preference for. Participants age ranged from 44-80 and therefore the most appropriate strategy was to include a range of music from different genres.

Participants were all recruited through emails and talks at Parkinson's UK meeting groups. Those interested in completing the research contacted the researcher. The group therefore self-selected. It may be the case that those participants may be more mildly affected by PD and therefore more willing to participate in research. All but one participant was undertaking various physical activities before the start of the current study, this differs from data from study two that suggested that only 26/61 were completing physical activity. It may be the case that participants had an interest in exercise and therefore may not be characteristic of the general population of those with PD. It would be interesting

to see whether a different effect would be seen with participants that were not already completing physical activity before completing the study.

Whilst investigating the mean scores, it is clear that mood scores for the current study were very low, specifically for anger-hostility (indicating positive mood). Out of a maximum of 48, the mean score was between 3 and 5 for the current study. This may suggest that were floor effects in the measures such that participants could not improve their mood as they were already scoring very near the maximum. This can also be seen in a number of dimensions for the PDQ-39, out of a range of 0-100, mean scores for social support were well into single figures. This suggests that participants were already scoring highly on the mood scale and had nowhere to improve.

Overall, this study did not see any physical or quality of life changes over time between pre and post assessments. This is to be expected as the lack of socialisation in the study would affect mood and quality of life rather than physical symptoms. There were however, some borderline significant results seen in mood. These findings would suggest that 'at home' exercise may have fewer benefits for those with PD than group sessions. This may be due to the social effect of group exercise and dance sessions that are not seen while exercising in isolation. There was however a trend for mood to improve following this study. With assessments one day after the last session, this may suggest that mood may be improved by 'at home' exercise.

This study used the same DVD resource as in study three. That study found immediate improvements following the music and movement task. The current study did not. The POMS was measured one day after the last session of each task. There are two reasons that this pattern of results may have happened. Firstly, mood improvements following 30 minutes of a music and movement task last for only a short period of time. Study three found significant improvements in mood immediately after this task and the current study, one day after the last session did not. It may be the case that these mood effects diminish before the current study was administered. The second reason could be that in study three,

the researcher was present at assessments, potentially creating a social resource for participants. In the current study, participants did not have a visit from the researcher for assessments. These were sent via email to participants, those with no internet access were contacted by telephone.

Another limitation of this study are the carry over effects. Although participants were counterbalanced, there may have been an initial effect of the intervention regardless of what that intervention was. In order to investigate this, the condition that participants completed first was compared from pre to post assessment, no significant improvements were had from time 1 to time 2 assessments.

In order to investigate this further, a final study investigating immediate effects of socialisation is required. As per the same methodology as study three, participants will be visited in their homes by the researcher. This will again be creating the potentially social environment of the researcher being present. This time however, participants will simply watch a 30 minute DVD, including the same music as the previous two studies. This study will however, include visuals designed to have no mood effects on participants whatsoever.

Chapter 9: Further investigation of immediate mood changes

9.1 Introduction

The main purpose of the current study was to investigate the effect of social interaction. Study three found immediate improvements in mood after participants completed exercises to music in their own home. The current study was designed to investigate these findings further, to explore whether in fact completing the activity brought about mood improvements or whether the social aspect of the researcher visit had an effect on mood. Following study three, participants expressed gratitude in participating in research (quotation from participant can be seen in chapter 6). This lead to questioning whether the results from study three were in fact due to the DVD or perhaps demand characteristics from the participants. The current study was designed to explore this in more detail.

9.1.1 Previous literature

The effect of social support on depression has been investigated in groups with and without PD (Cheng, Liu, Mao, Qian, Kangyong & Ke, 2007; Dimond, Lund & Caserta, 1987). Depression has been found to be related to social support, such that those with greater levels of social support reported lower levels of depression in the elderly (Holahan & Holahan, 1987). Golden, Conroy, Bruce, Denihan, Greene, Kirby and Lawlor (2009) investigated levels of social support and lonliness on mood and wellbeing in the elderly. This study interviewed 1299 people over the age of 65 in their own homes. This study identified that 35% of participants were lonely. It was found that loneliness and a lack of social resources were associated with depressed mood and wellbeing. This study would suggest that mood and wellbeing were negatively affected by a lack of social support. PD typically affects people over the age of 50 and therefore it is expected that levels of social support for these individuals would be similar to that of the elderly population.

This was also found in those with PD. Cheng et al. (2007) identified that in those with PD, non-depressed participants had significantly more social resources than those with depression. This would suggest that levels of social support are connected with mood, with previous research suggesting that those with depression tend to have fewer social resources. It is difficult to determine cause and effect here, but it is likely that both compound each other. These studies suggest that mood is negatively impacted by a lack of social resources.

Although this study focuses on the social engagement of the researcher being present, the current study included music overlaid onto the DVD. This is the same music that has been included in both study three and study four's DVD's. Study three found significant improvements in immediate mood effects following the DVD, and study four did not find any significant changes in mood. The key difference between these studies is the presence of the researcher. In order to keep the current study in line with previous studies in this research project, the same music will accompany the DVD.

Music has been shown to increase positive affect (McDermott et al. 2005) and decrease levels of depression and confusion (Sarkamo et al, 2008) in a range of conditions, such as those recovering from a stroke. Both Sarkamo et al. (2008) and Sarkamo and Soto (2012) suggested that listening to music daily had an impact on a number of outcome measures following a stroke. Both studies found improvements in mood over and above control groups as well as improved verbal memory and focused attention. Rigg (1964) suggested that tempo was the most important feature in determining mood levels.   This research has suggested that music alone can have an effect on mood, the music included in this study has previously been found to have no effect on mood after participants listened to half an hour per day for two weeks (chapter 7).

The study aim was to investigate whether immediate mood changes following a music and movement activity were due to the intervention or the social impact of the researcher. The current study will follow the same format of study three,

but participants watch 30 minutes of dance clips rather than completing the music and movement activity.

9.2 Method

9.2.1 Participants

Participants were 41 individuals diagnosed with PD. Recruitment for the current study was primarily conducted through participants that had completed study three, with 32 participants having completed the previous research. The other 9 participants were recruited through local Parkinson's UK support groups. A brief synopsis of the research was sent out to the local Parkinson's UK groups, and those interested in their research contacted the researcher directly. Emails were also sent to previous participants that had indicated they would like to be contacted for future research. As this research again involved visiting participants homes, participants were recruited within an hour and a half driving distance from the University of Hertfordshire.

9.2.2 Measures

Participants first completed standard demographic information. This included information such as length of time with disease and current medication. This was followed by the Hoehn and Yahr scale (Hoehn & Yahr, 1967) to assess disease severity. The dependent variable was a mood questionnaire, which was assessed by the BRUMS (Terry & Lane, 1993).

The participants were required to watch a 30 minute DVD of dance clips. The clips were a series of improvised dance clips portraying different emotions. These included neutral, angry and joyus moods. The moods were counterbalanced, with Neutral clips shown for the first and last five minutes of the clips. These clips were shown alongside the music from both study three and four.

9.2.3 Design

The current study is a 1X1 within subject design, with one independent variable; time, with two levels (pre and post assessment).

The dependent variable is mood (BRUMS)

9.2.4 Hypothesis
- There will be a no significant change in mood following this intervention

9.2.5 Procedures
The researcher visited participants' homes in order to complete the research. After signing the consent form, participants were asked some standard demographic questions as well as PD specific information, such as age at diagnosis, levels of medication. Participants were then given the Hoehn & Yahr scale as a measure of disease severity. This was followed with the BRUMS questionnaire. Once these questionnaires were completed, participants watched a 30minute DVD in the presence of the researcher. This DVD included a series of improvised dance clips overlaid with the music used in studies 4 and 5. Participants were required to passively watch the DVD. Following the DVD, participants were again given the BRUMS mood questionnaire and debriefed appropriately.

9.2.6 Statistical analyses
As per study three MANOVA was conducted on dependent variables that were theoretically grouped (BRUMS). Repeated measures ANOVA was conducted on the dependent variables that did not group (BRUMS TMD).

9.2.7 Ethics
Ethical approval was obtained from the School of Psychology Ethics Committee at the University of Hertfordshire. Protocol Number: **LMS/PG/UH/00400**

9.3 Results

Participants were 41 people with PD, 24 Male, 17 female. Each participant was rated for disease severity, with participants ranging from I to III on the Hoehn & Yahr scale (Hoehn & Yahr, 1967). Participant's demographic information can be seen in Table 9.1.

Table 9.1. Demographic information

	Male (N=24) M (SD)	Female (N=17) M (SD)	Total group (N=41) M (SD)
Age	71.33 (6.20)	68.71 (8.64)	70.24 (7.33)
Hoehn & Yahr	2.29 (.94)	1.91 (.78)	2.14 (.89)
Age diagnosed with PD	62.21 (8.74)	61.24(8.69)	61.80 (8.62)
Years with PD	9.12 (5.91)	7.47 (6.32)	8.44 (6.06)

The demographic information shows some mean differences between males and females in terms of how long they have had the disease and disease severity. This was tested using independent samples t-tests, there were no significant differences between the genders for these measures (p>.05). Participants were in the mild to moderate PD bracket as measured by the Hoehn & Yahr scale, the mean of 2.14 suggesting that participants were moderately effected by the symptoms of PD. On average, participants had been living with the disease for 8 years, although there was a large range from, 1 to 28 years since diagnosis.

There were 40 out of 41 participants taking medication for PD symptoms. One participant had recently stopped medication due to side effects and was waiting to see their Neurologist.

Table 9.2. Medication taken by participants

Medication	Frequency
Levodopa only	7
Dopamine Agonist only	2
Levodopa and Dopamine Agonist	25
Levodopa and MAO B inhibitor	2
Levodopa, Dopamine Agonist and MAO B inhibitor	1
Dopamine Agonist , Levodopa and Glutamate Agonist	3

*MAO B = Selective Monoamine Oxidase inhibitors

Levels and type of PD medication in the current study were in line with expectations, with Levodopa, Dopamine Agonists and a combination of the two being the most popularly prescribe drugs. A full explanation of the medications used to treat PD can be seen in appendix B.

Four participants were also taking an antidepressant alongside their medication. These were generally prescribed for reasons such as problems sleeping and pain (Amytriptaline and Clonezapam). One participant had been diagnosed with Depression by their GP and was taking an antidepressant for that (Mirtazapine).

BRUMS dimensions

A MANOVA was conducted for the dimensions of the BRUMS. Mean scores can be seen in Table 9.3. The data for these dimensions were slightly skewed (between 1 and 2), however this was deemed low enough to continue with the statistical test. This was the same for the correlation between dependent vairables, all DVs were below the acceptable correlation of .85, except the correlation between tension-anxiety and confusion-bewilderment which was .85.

Table 9.3. Mean scores for BRUMS pre and post

(N=41)	BRUMS pre M (SD)	BRUMS post M (SD)
Tension-Anxiety	2.36 (2.98)	1.0 (2.30)**
Depression-Dejection	1.51 (2.26)	.71 (1.60)*
Anger-Hostility	1.07 (1.85)	.71 (1.81)
Vigor-Activity	7.63 (3.65)	7.0 (4.47)
Fatigue- Inertia	3.59 (3.09)	2.98 (3.30)
Confusion - Bewilderment	1.59 (2.53)	1.10 (1.87)

A higher score indicates a higher level of that dimension, i.e. a higher Depression-Dejection score would indicate participants feel more depressed. ** $p<.001$, * $p<.05$.

A repeated measures MANOVA on the BRUMS dimensions revealed a significant improvement, $F(6,35) =6.11$, $p<.001$, $n\text{p}^2=.51$ for the model. This suggests that overall the dimensions of mood tested post task, showed an improvement from pre testing.

Follow up Univariate ANOVA's suggested that two out of the six of the dimensions improved over time. For tension-anxiety, there was a significant decrease in feelings of Tension over time, $F(1,40) = 17.84$, $p<.001$, $n\text{p}^2=.31$. For depression-dejection, there was a significant decrease in feelings of depression over time, $F(1,40) = 8.67$, $p=.005$, $n\text{p}^2=.17$. For anger-hostility, there was a significant decrease in feelings of anger-hostility over time, $F(1,47) =6.16$, $p=.017$, $n\text{p}^2=.13$. There were no changes in the levels of anger-hostility, vigor-activity, fatigue-inertia or confusion-bewilderment from pre to post assessments.

<u>BRUMS TMD</u>

BRUMS TMD was analysed using Repeated measures ANOVA between pre and post assessments. One data point was removed as an extreme case before statistical analysis.

The repeated measures ANOVA revealed no significant changes between time points, $F(1,38) =3.56$, $p=.075$, $n\text{p}^2=.079$. This suggests that there was no change in mood after watching the DVD.

In order to statistically control for medication, ANCOVA (POMS TMS) and MANCOVA (POMS dimensions) were conducted. This analysis revealed no significant differences from pre to post assessment in mood, $p>.05$.

9.4 Discussion

The main findings of the current study were that there was a main effect of mood from pre to post testing. Follow up univariate ANOVA's showed a significant improvement in feelings of tension-anxiety and depression-dejection. No changes were shown for anger-hostility, vigor-activity, confusion-bewilderment and fatigue-inertia in the presence of the researcher but without movement.

Overall this study has shown that when participants simply watch 30 minutes of dance, they have similar mood changes to completing exercise. This may suggest that the findings of study three may be have been affected by the social aspect of the researcher present rather than the movements that participants were completing. This suggests that an at-home DVD for participants would not have the same effects as shown in study three, as there would be no social aspect involved with this kind of resource.

In order to attempt to statistically control for the confound of medication, ANCOVA and MANCOVA were run for all outcome measures. No significant differences were observed for either outcome measure following this analysis. This may suggest that differences over time may have been moderated by medication. The limitations of this analysis are discussed in section 10.7.

The pattern of results up until this point has shown that when participants have completed dance and exercise tasks with a social aspect (study one, study three, and study five) there have been significant improvements in mood. Studies in which there has been no social engagement, and no researcher present (study two and study four) have shown no changes is mood. This programme of research can therefore suggest that social interaction within these kinds of tasks in those with PD is an important part of the enjoyment in completing them. This

is the first programme of research to investigate the effect of social engagement in dance and exercise in those with people with PD.

One issue with this study is that it could be said that simply watching the dance clips could be causing the improvement in mood. The clips were designed to show no mood changes, with just under half an hour of improvised contemporary dance movements. The dancers performing these clips were performing different emotions, with both positive and negative emotions being used in the DVD. These clips were interspersed with neutral emotion clips, and these neutral clips were also shown at the beginning and end of the video. The dance clips were shown to music, which may have had an effect on mood. The music used in study three was the same music used over the clips in study five. As there is a similar pattern of results for these two studies, the music may have been having the effect on mood levels.

Those with PD are known to have a deficit in dopamine levels (Lotharius, and Brundin, 2002) which has been implicated in changes in mood levels (Ashby, Isen and Turken, 1999). Ashby et al. (1999) describe the dopaminergic theory of positive affect. This suggests that the event causing the increased mood stimulates the substantia nigra (and in turn releases dopamine), which also leads to an increase in motor activity. This may suggests that an increase in mood may have symptomatic implications for those with PD. Animal studies have also shown that listening to music can increase dopaminergic transmission and dopamine concentrations (Sutoo, 2004). Therefore, there seems to be a link with music increasing mood, which may stimulate dopamine production and motor movement. Therefore, the music overlaying the clips may have had an effect on the findings of this study. With that said, participants in study four listened to this music and completed exercises to this music and found no significant effect of mood.

The current study has shown that simply giving participants a passive task (such as watching a series of dance clips) has a significantly positive effect on mood. This task has shown that whether the participants were affected by the social

impact of the researcher or the music overlaying the DVD, that mood improvements are not solely down to moving to an exercise to music DVD as though after study three. This study shows that mood improvements shown in study one, may not be exclusively affected by the dance sessions and could have been due to the socialisation of attending a group class. The previous studies in this programme have shown that even the social effects of the researcher may have been affecting mood levels in those with PD.

This research may have suggested that mood can be affected by social interaction more than initially anticipated. Research described above using rat models (Sutoo, 2004) described the effect of mood on the dopaminergic system which may have an effect on movement. These changes in mood may have had an effect in previous literature that has found significant improvements in motor functioning following dance studies.   This theory would suggest that an increase in mood may stimulate the substantia nigra to release dopamine and therefore have an indirect effect on movement.

Chapter 10: Discussion

10.1 Overview of the programme of research

This programme of research has investigated the effect of both dance and exercise to music on mood and other outcome measures. This research has shown that mood is improved in those with PD following both dance classes, and exercise to music without the social context of a group session.

The programme of research set out to partially replicate previous findings indicating that dance has a significant improvement on physical symptoms, and investigate previously unexplored psychological and cognitive changes following dance. Study one failed to replicate balance improvements that have been shown after a variety of types of dance. This study did however, investigate novel outcome measures that had not been investigated previously, finding social dances can have a short and longer term effect on mood. When investigating mood levels of participants that were already completing a variety of social activities, there were no differences between groups completing dance, exercise, other activities and no social activities for levels of mood.

Home based research, showed mood changes immediately after participating in a music and movement DVD, but longer term effects were not seen in study four in which participants competed the same DVD in their own home over a two week period. Finally, watching dance in the presence of the researcher, showed some improvements in mood, although not as strongly as study three. This pattern of results shows that study one, three and five showed improvements in mood, and study two and four did not. Social aspects of the research may be able explain these findings. Study three was conducted in participant's home, without the social aspect of a dance group. The researcher however, was present in the participant's home while they completed the task. This was also the case in study five. When the researcher was not present in study four, no changes in mood were observed. When a cross sectional study comparing real world social groups, there was no association between type of activity and mood.

Further analysis of studies one, three and five identified that when the effect of medication was included as a covariate, the significant effects of mood disappeared. Implications of this are discussed in more detail in section 10.6.

The only study to show changes in mood, not immediately after a dance session, was study one. This however, may be due to the social nature of the assessment day. Participants all arrived at the lab for a secondary assessment in which a mood score was taken. This in itself is a social event and may have had an effect on mood scores. It may be the case that in fact changes in mood throughout this programme of research may be due to social and 'healing balm effects' rather than dance and exercise. This programme of research shows that the reasons underlying the mood changes following dance and exercise to music are not clear cut and there may be more of a social explanation that previously thought.

10.2 Discussion

The aim of this body of research was to investigate the effect of dance on those with PD. The research was motivated by a limited pool of research suggesting that there may be an effect of dance on the physical symptoms of PD. When beginning this body of work there were eight experimental papers investigating this, of these, four papers were published separately but discussed the same experimental study. These papers predominantly came from the same laboratory, with only one of these papers not published from the same researchers.

These papers predominantly focused on the role of Argentine tango on the physical symptoms of PD, although other dance forms were explored such as waltz/foxtrot and contact improvisation. The overall impression from these initial papers suggested that there may be a physical benefit following dance sessions. This initial research focused on balance and mobility using the outcome measures UPDRS, TUG and BBS, showing an indication that balance and mobility could be improved following dance. This initial research tended neglect non motor symptoms of PD, and focus on balance and mobility. Hackney & Earhart (2009a) were the first to include a quality of life measure in which the

tango group significantly improved overall, also for mobility and social support dimensions, whereas the waltz/foxtrot, tai chi and control groups did not. The literature review in chapter 1 details the benefits found for each of these experimental studies in each domain.

These papers suggested that tango may be more beneficial than other forms of dance. Hackney & Earhart (2009a) suggested tango to be more beneficial than a waltz/foxtrot group over 10 weeks for motor severity as measured by the UPDRS III and quality of life. Interestingly improvements in balance were seen for all three experimental interventions (tango, waltz/foxtrot and tai chi). Within Marchant et al (2010), comparisons between contact improvisation and the tango group described in Hackney & Earhart (2009b) were made. The paper concluded tango to be marginally superior to contact improvisation in terms of physical benefits, this claim not supported by the data. At this point, the research gave us a preliminary indication that dance may be beneficial for PD, but a number of symptoms, intervention lengths and formats required further investigation.

A meta-analysis was conducted on the previous dance for PD research in chapter 4. This study found significant improvements in BBS, TUG and UPDRS III in the previous literature. This links with Lötzke et al. (2015) that found the same pattern of results when including only studies investigating the effect of tango on the symptoms of PD. This meta-analysis suggests that the previous literature regardless of type of dance had a significant improvement in those three outcome measures. This contradicts previous literature that has suggested that tango may be a superior form of dance for those with PD and dance. These dance studies include social music and movement aspects of the interventions. Therefore, it may be the case that it is not dance uniquely having an effect on participants, but activities that include both of these characteristics. Further research is required to effectively explore this further to determine whether dance is specifically promoting improvements in physical abilities in those with PD or whether it is simply activities that include social interaction, movement and music.

To investigate further two studies replicated and built on previous literature, from that point a number of questions raised and the further studies investigated effects of home based research in people with PD.

The first study in this programme of research was investigating social dances on the symptoms of PD. This study failed to find any significant improvements in balance following dance. This study did however, find a significant improvement in the dimension of communication within the PDQ-39. This study also investigated the effect of short term and longer term effect of mood. Significant improvements in both mood were found following the dance study, and also immediately after a class. This was the first study to investigate mood in the dance for PD research. A paper discussing these mood results following dance has been published (Lewis, Annett, Davenport, Hall and Lovatt, 2014).

This initial study raised a number of questions regarding the effect of social group, the effect of music and the movement aspect of dance. The study found novel findings into the effect of mood in those with PD following social dance sessions. In order to investigate mood levels of different social groups a cross sectional survey study was employed. Participants with PD were contacted to complete a survey exploring the different social activities being attended by those with PD and whether there were any differences in mood levels of those completing these activities in their everyday lives. This study aimed to investigate whether those with PD completing differing forms of social activity (dance, exercise, other social activities and no activities) had any variations in mood. This study found no significant differences in mood between the differing social groups. This study suggested that mood levels were consistent across the groups regardless of what type of activity was being regularly completed. Mean scores for mood levels were lower than post assessment mood scores following study one. As participants completed the survey in their own time, it is unknown the amount of time between activity and mood scale. One explanation for these findings could be that mood changes following activity may have a relatively short term effect on mood. Participants will have differed for the amount of time since the last activity was completed which may have had an effect on mood

scores. In order to investigate whether mood was affected by a short activity that involved music and exercise without the social aspect of a dance class, study three was conducted.

Study three was an 'at home' study for people with PD.   Participants completed a 30 minute music and movement task in their own homes with a mood questionnaire immediately before and after the task. This study found significant improvements in overall mood, and all dimensions of the BRUMS except fatigue-inertia significantly improved following the task. This is the first time mood has been explored after an 'at home' exercise to music DVD activity. This study showed that the mood of participants significantly improved on all measures (except fatigue-inertia) following 30 minutes of exercise to music without the social impact of a group class. One issue with this study was that the researcher was present for the task. It became clear throughout testing that participants enjoyed being involved in the research and often became an event for participants. This differs from the socially isolated task that the study was aiming to explore.

To this point, the pattern of results show that when participants are completing a 10 week social dance intervention, participants have significant improvements in mood both short term and longer term. This was not seen when getting a cross section of people involved in this type of activity in everyday life. Short term mood was again seen to improve in the short term following a music and movement DVD in participants own homes. The researcher was present in both study one and study three but not in study two.

For study four, the same resource was sent to participants to complete two week interventions of a DVD. Participants completed two weeks of listening to music for 30 minutes per day, completing 30 minutes of exercises to the DVD and two weeks of completing these exercises to music. This study had no social impact of the researcher, and was sent to participants to complete each day. Participants met the researcher for the initial assessment, but all follow up assessments were completed via email or telephone. No significant effects of mood, quality of life

or self reported symptoms were seen following any of these three conditions. This study did not have the social impact of the researcher. This pattern of results were beginning to suggest that the researcher may have been a confounding variable.

Study five was created to investigate this further. This study followed the same format of study three, with participants being visited by the researcher in their own homes. This study included the same mood measure before and after a 30minute DVD. This DVD however, was designed to have no effect on mood. The DVD included the same music used on the other two studies (study three and five), but the content was to passively watch contemporary dance. This DVD was made up of dance clips designed to portray no emotion to the viewer. This study found significant improvements in a number of the BRUMS dimensions. Findings did not follow the exact pattern of study three, however participants significantly improved on overall mood and on the dimensions of tension-anxiety and depression. These findings would suggest that the social impact of the researcher was having a significant effect on the mood of participants.

In conclusion, this programme of research has explored the effect of dance and exercise to music on those with PD. The research has suggested that mood can be significantly improved following dance and exercise to music. The effect of the social group appears to have an effect on mood. Although studies in this programme of research aimed to explore exercise to music activities without the social group, it became clear that the researcher may have been acting as a social confounding variable. The research suggests that these type of interventions are beneficial for those with PD in terms of mood, but the picture is far from clear.

10.3 Future directions

This research has begun to explore the effect of dance and exercise to music on mood levels. The findings have shown that the social impact of classes and even the researcher are key. This programme of research has raised a number of questions regarding the social impact of dance and exercise to music sessions and what aspects of these sessions are important to show improvements in

different domains in people with PD.

The next logical study would be a large scale research project investigating dance and other social activities in a lab based setting. This would include four experimental groups and one control group.

1. Dance group
2. Exercise to music group
3. Exercise only group
4. Social activity group (non movement activity)
5. Control group

This study would involve a ten week intervention in which participants were tested for mood changes immediately before and after an intervention activity and pre and post the ten weeks. Physical changes would also be explored as the meta-analysis suggested that dance is beneficial for the BBS, TUG and UPDRS III. This would explore the effect of dance and exercise in greater depth. In which groups could be compared for levels of mood both short term and longer term (to mirror study one), but also compare whether there are differences between dance and exercise to music, and whether changes could be observed for exercise only (with no music interaction). The social only group would compare whether improvements in were also seen in a social, non movement group.

Groups one to three would wear accelerometers to measure the intensity of activity, this could be controlled to ensure all three activity groups were expending the same levels of energy so not to confound results. The findings from this study would compare whether there is something special about dance for those with PD or whether exercise to music could bring about similar changes. The effect of social group would be really interesting to measure to investigate how beneficial a social group with no activity could be both for mood and physical measures.

10.4 Implications

This programme of research has a number of implications for those with PD. Firstly, research has found that dance is a feasible form of exercise for those with PD. There were no adverse incidents that took place during any of the research undertaken. Dance is a safe way for those with PD to participate in physical activity.

The research has also found significant mood improvements following dance and exercise to music both over the longer term (10 weeks) and immediately after completing these activities. This form of exercise is beneficial psychologically for those with PD. This is important due to the high levels of depression reported in those with PD.

The research failed to find significant improvements in mood when there was no social input from a group or the researcher. This suggests that for those with PD, the most beneficial for of dance and exercise to music is whilst completing this with others, rather than alone.

There are also a number of implications for other researchers in this field to take note of following this programme of research. The pattern of improvements, physically, psychologically and cognitively are not clear-cut following dance. Study one found no significant improvement in balance but as the meta-analysis showed, other papers in this area have. Further work on more sensitive measures are required to explore this area further to understand the exact changes that are happening following dance. Various studies have explored quality of life following dance, this is an even further complicated pattern and requires more detailed exploration using more sensitive tools. This field will always be difficult to explore due to the nature of PD and differences in symptoms from person to person. Patient specific tools may be a more viable and useful option going forward.

There is also a need to explore the mechanisms for why dance may be beneficial for those with PD both physically and psychologically. The thesis has described

the possible explanation of external cues bypassing dysfunctional areas of the brain but this is currently speculative. If research were to find the mechanistic explanation for the benefits of dance and music to movement, then a more precise prescription of activity could be provided for those with PD incorporating only the most beneficial techniques and movements.

10.5 Impact

This programme of research has explored the effect of dance and exercise to music on those with PD. One of the biggest issues faced throughout this research has been recruitment. Recruiting participants to attend the University was almost impossible, and studies in this programme of research were subsequently modified for the researcher to go out to participants. As part of this research, dance for PD classes at the University were set up to both provide a service for local people with PD but also attract participants to the University and develop relationships for future research projects.

Dance for PD classes were set up in June 2015, and are running weekly at the University, which are being managed by the researcher. Classes are developing and now regularly have around 15 people with PD in attendance each week attending with their partners and carers. These classes are a great resource for people with PD and many are subsequently involved in research at the University as a result.

10.6 Mechanisms

The previous literature has suggested that dance can be beneficial for those with PD. The meta-analysis in Chapter 4 identified three key outcome measures that have seen change throughout the research, notably the UPDRS III, TUG and the BBS. No changes were observed in the previous research for the 6MWT and PDQ-39 rating scale. These of course, are only the outcome measures most commonly used in the research and therefore not to say that dance is not having a benefit on other measures that are not more commonly administered. There has been a distinct lack of research exploring the mechanisms in which different forms of dance have on those with PD, and why they have a benefit for some

symptoms and not others. Why is it that the TUG can be significantly improved by dance but the 6MWT not?

The previous research has suggested a number of explanations for why dance may be beneficial for those with PD. Although some papers fail to explore the reasons for why dance may be beneficial for certain symptoms of PD, those providing theories of mechanisms tend to focus on the basal ganglia. No empirical research has been conducted into the mechanisms for why dance would have a beneficial effect on physical and psychological aspects of PD.

The most common explanation of the mechanisms involved has been described a number of times by Hackney & Earhart (Earhart, 2009; Hackney & Earhart, 2007, 2009a; 2009b; 2009c) that suggested synchronising movements to a rhythmic beat may stimulate areas of the brain that have reduced function in those with PD. As discussed in chapter 1, those with PD have a deficit in the basal ganglia due to dopamine loss. Hackney & Earhart suggest that dancing actively stimulates the basal ganglia, which in this disease has reduced activation. This is a potential explanation of why changes in motor abilities have been observed following dance in those with PD. Hackney & Earhart (2009c) also suggested that this activation in the putamen could have an effect on non motor symptoms of depression and anxiety. The researchers suggest that decreased dopamine in the putamen has been correlated with these symptoms (Weintraub et al, 2005) and therefore activation in this part of the brain can improve quality of life through reduction of depression and anxiety. This explanation is predominantly based on the findings of Brown (2006). One critical issue with this study is the nature of the 'dance' task. The method explains the process of the PET scan whilst completing the different movements. This was all together, quite a different experience to dancing in a social situation. Participants were injected, with their heads strapped still and asked to keep bodily movements to a minimum. Although the findings suggest difference between the conditions, it is difficult to conclude the findings are related to dancing and entrainment to music. This experience would have been a stressful and very different one than the participants were used to.

This explanation does not explain why different forms of dance would have an effect on the symptoms of PD. Contact improvisation is a very different type of dance than tango, and does not typically follow a beat. Marchant et al. (2010) found similar improvements to tango after participants completed contact improvisation. This paper compares contact improvisation and tango (Hackney & Earhart, 2009a) directly and the only difference being those completing the contact improvisation showed a borderline significant improvement in the TUG. The explanation that moving predictably to a strong beat activating the putamen and therefore increasing motor movement does not explain the findings of Marchant et al (2010).

The role of external cues has a substantial background and has been found beneficial in walking (See Chapter 2). The majority of previous literature has focused on RAS, which differs from dance steps to music. However, dance does include a number of cues from different sources, and not just through a strong beat of music. This again is only the case of dances that use these cues. Contact improvisation is very different to the other forms of dance explored and does not follow these parameters, with no strong beat, or cue on movements from the teacher. There are however, sensory cues as participants often work with a partner, counterbalancing weight and moving together. The role of cueing does seem likely to be involved in the dance for PD research and could be a potential mechanism working to improving a number of outcome measures as we have seen in the research.

Dance classes have been described as an enriched environment (Heiberger et al, 2011), including aerobic activity, multitasking, cognitive and physical challenges, balance, co-ordination, expression of emotions, musical beat and co-ordination. These aspects are not seen in most other activities. This environment may be very different from those with PD daily lives. These aspects of the dance class may have beneficial effects on neuroplasticity (Kattenstroth et al, 2010). Farley, Fox, Ramig & McFarland (2008) suggested that neuroplasticity in PD can be enhanced in environments with key principles. As dopaminergic neurones are

194

greatly affected by physical activity, exercises that are complex and intensive and introduced early in disease progression can have a beneficial effect. Dopaminergic neurones are greatly effected by reward based behaviour, with up to 80% being activated by rewarding activities (Natbony et al,2013). We know that dance has a positive effect of mood (Lewis et al, 2014), enjoying an activity in itself is rewarding and may have an effect on the dopamine reward system. This may increase levels of dopamine in the brain and lead to improvements in movement.

This explanation would tie together all dance types regardless of music or dance steps. Previous research has noted that participants enjoyed the research, through exit questionnaires and qualitative research (Houston & McGill, 2013). Enjoyment of the activity in an enriched environment may have a positive effect on symptoms of PD. This however, would not explain why some outcome measures showed improvements after dance sessions and others not (see meta-analysis).

With that said, Houston and McGill (2013) suggested that participants confidence grew throughout the study and that 'participants were moving in ways in which they were probably already capable of doing, but did not have the courage, or the circumstances, to try.' This may suggest that in fact dance may not be having such a physical effect on participants, but that as their confidence grows and fear of falling abates, participants are able to move more easily.

The previous mechanisms are assuming that dance is significantly different to exercise in its mechanisms. Only four papers have compared dance to exercise, two of these were from the same research study (Hackney & Earhart, 2007a;2007b; Hashimoto et al, 2015; Romenets et al, 2015). These papers did suggest that dance may be more beneficial to exercise, but the idea that the mechanisms would be completely different has not been explored in enough detail. Both Hasimoto et al (2015) and Romenets et al (2015) included exercise groups, although these were not controlled as the dance sessions, without instructors and self directed. Dance forms that are very different from one

another, such as contact improvisation and tango have both found positive effects in similar domain. It may be the case that simply exercising in a novel way may be beneficial for these outcome measures. It is unclear whether there are different mechanisms in play rather than simply completing physical activity in a friendly atmosphere.

The above theories of for why dance may have an effect on PD can explain some of the changes seen by participants in the previous research. It is likely that there is more than one mechanism at play in the changes observed in those with PD. We do know that dance has been shown to be enjoyable to participants, which may have an effect on the dopaminergic reward system. Cues have also been widely used in the past to help those with PD to overcome obstacles. Although dance does not use all of the aspects of RAS, there are a number of external cues that can help people with PD to improve their physical symptoms. It has also been suggested that activation of the basal ganglia has may have beneficial effects for both physical and non-physical symptoms of PD such as a decrease in feelings of depression and anxiety. The relevant studies have not yet been conducted in order for us to truly understand the mechanisms for why dance is beneficial for those with PD.

The meta-analysis in chapter 9 suggested that the BBS, UPDRS III and TUG significantly improved following dance sessions, but there were no overall changes seen for the PDQ-39 and 6MWT. What is it about these three outcome measures that showed change after dancing but the other two would not? The meta-analysis showed that both the BBS and UPDRS III were the most strongly associated with improvements with very few studies showing no change from pre to post assessments. These two outcome measures are similar in that they are made up of a number of activities in which a physiotherapist rates. This may show changes in participants all round movement more effectively than the other outcome measures. Dance classes do not solely focus on one part of the body, but the participant as a whole. It may be the case that as the dance sessions is focusing on footwork, arms placement and posture that the full body outcome measures are more sensitive to pick up changes overall. The TUG also

showed significant improvements in the meta-analysis, although the individual studies had more of a mixed response.

The TUG is a rather short task, but does include a number of activities, such as rising from a chair, walking, manoeuvring around a chair and then sitting back down. This task does include a number of essential activities that could have been affected by the dance sessions, getting in and out of a chair, walking, turning and balance. This differs to the 6MWT that is just one aspect of the disease, walking ability. In this task, participants are required to walk as far as possible in six minutes. This is a rather crude measure as it simply measuring speed and distance. It is not known whether participants' stride or gait improved simply by the distance they walked.

Overall it is difficult to suggest a mechanism that would show this pattern of results, as said previously it is likely to be more than one mechanism at work. It could be suggested that if external cues were the mechanism in which participants improved, there would be a significant improvement in 6MWT. The previous literature has tended to focus on walking ability after auditory cues especially. The previous literature showed no changes in overall walking ability following dance sessions.

10.7 Research limitations

One of the biggest issues faced throughout this programme of research was recruitment. Recruiting those with PD was more difficult than anticipated and took significantly more time than expected. The bulk of recruitment was run through Parkinson's UK, visiting local support groups and through their research support network (mailing list of those with PD interested in participating in research). This has led to our samples being volunteers from local groups and people interested in research. Those with PD, not involved with the support groups were not accessible and therefore could not be recruited successfully. Due to the nature of recruitment through this method, the pool of participants was limited to those with an interest in research and specifically those interested in dance and exercise research. This may have led to a biased sample. A number

of participants were put off from completing the research because of the word 'dance'. As the programme of work continued, changing of wording on accompanying documents did improve this, but again there were some people that were simply not interested in completing research into this topic. These connections formed with the PUK groups throughout the research have led to strong relationships with the University and local (and slightly less local) PD groups.

For studies four, five and six, the research was conducted in participants' homes. This decision was partially due to the lack of participants in the local area able to attend the University. Participants were often unable to travel for the research and recruitment proved very difficult and time consuming. The researcher individually attending participant's homes increased the number of participants interested in completing the research tremendously.

These issues with recruitment have led to low sample sizes in each of the research studies. With a sample as varied as those with PD, large sample sizes are important to account for the differences in symptoms from this population. With that said, this group is specialised and therefore low sample sizes have been seen throughout the previous research. Although we always strive for large samples in order to generalise the findings to others with the disease, low sample sizes are a feature of the majority of the research presented in this topic area.

There have also been a number of issues associated with the outcome measures used in the previous research. The current research project has used similar outcome measures to previous research, in order to be directly comparable. PD is a heterogeneous disease with a number of symptoms appearing at different times and severity, which differs wildly between those with PD. Zetusky, jankovic & Pirozzolo (1985) suggested that there are at least two subsets of PD, those with tremor as the main symptom, and others with Bradykinesia and postural instability. With this in mind, it has proved difficult to compare different symptoms with reference to intervention success. The previous

research has found significant improvements for some outcome measures and not others. The TUG for example, overall was found to have a significant improvement following dance, although there were a number of studies that found no changes after the intervention. With a group that differs so wildly, it makes sense that change following an intervention would be different for those suffering from different symptoms. For example, those with the main symptom of slowness of moving, may have improvements following a certain form of dance, and could be observed through the timed up and go. Another person with PD may have no slowness of moving and therefore may not show any changes in the same outcome measure.

Within chapters 5, 7 and 9, analysis was conducted to control for the effect of medication on results. This analysis concluded that medication may have had an significant impact on results within this program of research, when medication was controlled for, effects of the interventions were reduced and changes in mood disappeared. This analysis however, has its own limitations in respect to statistical power and should be treated with caution. It is worth noting that due to the variety of medication types taken by participants (Levodopa, Dopamine Agonists, COMT inhibitors, MAO-B inhibitors and a combination of these) and the small sample sizes of the current studies make it difficult to make any firm conclusions from this analysis. Further exploration of the effect of medication is required to understand how this impacts mood. Future studies should aim to investigate this further or aim to control for the effects of medication through sampling.

10.8 Conclusions

This programme of research has shown that dance and exercise to music can be beneficial for those with PD. Study one showed that social dances have a number of significant benefits. The research did not find the same physical benefits as seen in some of the previous research (Hackney & Earhart, 2009a; 2009b; Duncan & Earhart; Hasimoto, 2015; Marchant, 2010; Romenets, 2015), but interestingly, showed mood improvements. An at home DVD of music and movement was suggested to have significant mood improvements following just

one session. Study five sought to investigate the social aspect of the research, with participants watching 30 minutes of dance, without any movement. Although there were some mood improvements observed during the study, these were not as substantial as those in following participants completing an exercise to music task. These results suggest that the social aspect of the research did have some bearing on the mood of participants following both 'at home' tasks.

Mood improvements following dance and music and movement are important for those with PD. As discussed previously, those with PD have increased levels of depression and anxiety, over double the level of other disabled patients (Cummings and Masterman, 1999). The exact reason for why those with PD have an increased prevalence is unknown. The findings from this programme of research suggest that mood improvements can be seen following dance and exercise to music, these findings are especially important to alleviate some of these negative aspects of mood.

There are a number of unanswered questions throughout the research. In terms of study one, more empirical methods of measuring physical changes are required. A number of the outcome measures are subjective therefore are interpreted in different ways depending on the rater. As discussed previously, it is unknown the optimal length of intervention or form of dance, and these questions require answering to create the most effective intervention for those with PD. An at home DVD appears a promising resource, to improve mood, however this has been shown to be moderated by the presence of the researcher.

This programme of research has shown that dance can be beneficial for those with PD and found novel improvements in mood and problem solving. Exercise to music has also been shown to be beneficial in terms of mood, but that there is a social effect that is happening within the research. Mood changes appear to be effected by the presence of the researcher, studies in which the researcher was not present appeared to have no differences in mood. These findings suggest that there is a complex effect of dance and exercise research in terms of movement and socialisation.

References

Aarsland, D., Andersen, K., Larsen, J. P., Lolk, A., & Kragh-Sørensen, P. (2003). Prevalence and characteristics of dementia in Parkinson disease. *Archives of Neurology,* 60, 387-392.

Alpert, P. T., Miller, S. K., Wallmann, H., Havey, R., Cross, C., Chevalia, T., . . . Kodandapari, K. (2009). The effect of modified jazz dance on balance, cognition, and mood in older adults. *Journal of the American Academy of Nurse Practitioners*, 21(2), 108-115. doi: 10.1111/j.1745-7599.2008.00392.x

Ascherio, A., Chen, H., Weisskopf, M. G., O'Reilly, E., McCullough, M. L., Calle, E. E., ... & Thun, M. J. (2006). Pesticide exposure and risk for Parkinson's disease. *Annals of Neurology*, *60*(2), 197-203.

Ashburn, A., Roberts, L., Pickering, R., Roberts, H. C., Wiles, R., Kunkel, D., . . . Fitton, C. (2014). A design to investigate the feasibility and effects of partnered ballroom dancing on people with Parkinson disease: randomized controlled trial protocol. *JMIR Research Protocols*, 3(3).

Ashby, F. G., & Isen, A. M. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review*, 106(3), 529.

Baatile, J., Langbein., Weaver, F., Maloney, C., & Jost, M. (2000). Effect of exercise on perceived quality of life of individuals with Parkinson's disease. *Journal of RehabilitationRresearch and Development,* 37(5), 529-534.

Batson, G., Migliarese, S. J., Soriano, C., H. Burdette, J., & Laurienti, P. J. (2014). Effects of improvisational dance on balance in Parkinson's disease: a two-phase fMRI case study. *Physical & Occupational Therapy In Geriatrics*, 32(3), 188-197.

Batson, G (2010). Feasibility of an intensive trial of modern dance for adults with Parkinson disease. *Complementary Health Practice Review*, 15(2), 65-83.

Beck, A. T., Ward, C., & Mendelson, M. (1961). Beck depression inventory (BDI). *Arch Gen Psychiatry*, 4(6), 561-571.

Bengtsson, S. L., Ullen, F., Henrik Ehrsson, H., Hashimoto, T., Kito, T., Naito, E., . . . Sadato, N. (2009). Listening to rhythms activates motor and premotor cortices. *Cortex,* 45(1), 62-71.

Berg, K., Wood-Dauphinee, S., & Williams, J. I. (1995). The Balance Scale: reliability assessment with elderly residents and patients with an acute stroke. *Scandanavian Journal of Rehabiliatation Medicine*, 27(1), 27-36.

Bernatzky, G. N., Bernatzky, P., Hesse, H.P., Staffen, W., & Ladurner, G. (2004). Stimulating music increases motor coordination in patients afflicted with Morbus Parkinson. *Neuroscience Letters,* 361(1), 4-8.

Blandy, L. M., Morris, M. E., & Beevers, W. A. (2015). Therapeutic Argentine tango dancing for people living with Parkinson's disease: a feasibility study. *Frontiers in Neurology,* 6, 122.

Bohannon, R. W (2006) Reference values for the timed up and go test: A descriptive meta-analysis. *Journal of Geratric Physical Therapy. 29* (2), 64-68.

Bohannon, R. W. (2007). Six-Minute Walk Test: A meta-analysis of data from apparently healthy elders. *Topics in Geriatric Rehabilitation*, *23*(2), 155-160.

Braak, H., & Del Tredici, K. (2008). *Neuroanatomy and pathology of sporadic Parkinson's disease (Vol. 201)*: Springer.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology,* 3(2), 77-101.

Brod, M., Mendelsohn, G. A., & Roberts, B. (1998). Patients' experiences of Parkinson's disease. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 53(4), P213-P222.

Brooks, D. J. (2000). Dopamine agonists: their role in the treatment of Parkinson's disease. *Journal of Neurology, Neurosurgery & Psychiatry*, *68*(6), 685-689.

Brown, S., Martinez, M. J., & Parsons, L. m. (2006). The neural basis of human dance. *Cerebral Cortex*, 16(8), 1157-1167.

Brown, L. A., de Bruin, N., Doan, J. B., Suchowersky, O., & Hu, B. (2009). Novel challenges to gait in Parkinson's disease: the effect of concurrent music in single- and dual-task contexts. *Archives of Physical Medicine and Rehabilitation*, 90(9), 1578-1583.

Butland, R., Pang, J., Gross, E., Woodcock, A., & Geddes, D. (1982). Two-, six-, and 12-minute walking tests in respiratory disease. *British Medical Journal (Clinical Research Education.),* 284(6329), 1607-1608.

Byrne, A., & Byrne, D. (1993). The effect of exercise on depression, anxiety and other mood states: a review. *Journal of Psychosomatic Research*, 37(6), 565-574.

Camicioli, R., Gee, M., Bouchard, T. P., Fisher, N. J., Hanstock, C. C., Emery, D. J., & Martin, W. (2009). Voxel-based morphometry reveals extra-nigral atrophy patterns associated with dopamine refractory cognitive and motor impairment in parkinsonism. *Parkinsonism & Related Disorders*, 15(3), 187-195.

Campion, M., & levita, L. (2014). Enhancing postivie affect and divergent thinking abilities - Turn up the music and dance. *The Journal of Positive Psychology*, 9(2), 137-145.

Canning, C. G., Ada, L., Johnson, J. J., & McWhirter, S. (2006). Walking capacity in mild to moderate Parkinson's disease. *Archives of Physical Medicine and Rehabilitation*, *87*(3), 371-375.

Cerasa, A., Hagberg, G. E., Peppe, A., Bianciardi, M., Gioia, M. C., Costa, A., . . . Sabatini, U. (2006). Functional changes in the activity of cerebellum and frontostriatal regions during externally and internally timed movement in Parkinson's disease. *Brain Research Bulletin*, 71(1), 259-269.

Cheng, Y., Liu, C., Mao, C., Qian, J., Liu, K., & Ke, G. (2008). Social support plays a role in depression in Parkinson's disease: A cross-section study in a Chinese cohort. *Parkinsonism & Related Disorders*, 14(1), 43-45.

Chiong-Rivero, H., Ryan, G. W., Flippen, C., Bordelon, Y., Szumski, N. R., Zesiewicz, T. A., ... & Vickrey, B. G. (2011). Patients' and caregivers' experiences of the impact of Parkinson's disease on health status. *Patient Related Outcome Measures*, *2011*(2), 57.

Cohen, J. (1988). *Statistical power analysis for the behavioural sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Corrigan, F. M., Wienburg, C. L., Shore, R. F., Daniel, S. E., & Mann, D. (2000). Organochlorine insecticides in substantia nigra in Parkinson's disease. *Journal of Toxicology and Environmental Health Part A*, *59*(4), 229-234.

Crizzle, A. M., & Newhouse, I. J. (2006). Is physical exercise beneficial for persons with Parkinson's disease? *Clinical Journal of Sport Medicine*, 16(5), 422-425.

Crowther, R. D., & Durkin, K. (1982). Sex-and age-related differences in the musical behaviour, interests and attitudes towards music of 232 Secondary School Students. *Educational Studies*, *8*(2), 131-139.

Cruise, K., Bucks, R., Loftus, A., Newton, R., Pegoraro, R., & Thomas, M. (2011). Exercise and Parkinson's: benefits for cognition and quality of life. *Acta Neurologica Scandinavica,* 123(1), 13-19.

Cummings, J. L. (1992). Depressions and Parkinson's Disease: A review. The *American Journal of Psychiatry*, 149(4), 443-454.

Dauer W and Przedborski S (2003) Parkinson's disease: Mechanisms and models, *Neuron*, 39:889-909

De Bruin, N., Doan, J. B., Turnbull, G., Suchowersky, O., Bonfield, S., Hu, B., & Brown, L. A. (2010). Walking with music is a safe and viable tool for gait training in Parkinson's disease: the effect of a 13-week feasibility study on single and dual task walking. *Parkinson's Disease*, 2010.

De Dreu, M., Van der Wilk, A., Poppe, E., Kwakkel, G., & Van Wegen, E. (2012). Rehabilitation, exercise therapy and music in patients with Parkinson's disease: a meta-analysis of the effects of music-based movement therapy on walking ability, balance and quality of life. *Parkinsonism & Related Disorders*, 18, S114-S119.

Dibble, L. E., Hale, T. F., Marcus, R. L., Gerber, J. P., & LaStayo, P. C. (2009). High intensity eccentric resistance training decreases bradykinesia and improves quality of life in persons with Parkinson's disease: a preliminary study. *Parkinsonism & Related Disorders*, 15(10), 752-757.

Dimond, M., Lund, D. A., & Caserta, M. S. (1987). The role of social support in the first two years of bereavement in an elderly sample. *The Gerontologist, 27*(5), 599-604.

Drago, V., Foster, P., Skidmore, F., & Heilman, K. (2009). Creativity in Parkinson's disease as a function of right versus left hemibody onset. *Journal of the Neurological Sciences*, 276(1), 179-183.

Dubois, B., Slachevsky, A., Litvan, I., & Pillon, B. (2000). The FAB A frontal assessment battery at bedside. *Neurology*, 55(11), 1621-1626.

Duncan, P. W., Weiner, D. K., Chandler, J., & Studenski, S. (1990). Functional reach: a new clinical measure of balance. *Journal of Gerontology*, 45(6), M192-M197.

Duncan, R. P., & Earhart, G. M. (2012). Randomized Controlled Trial of Community-Based Dancing to Modify Disease Progression in Parkinson Disease. *Neurorehabilitation and Neural Repair*, 26(2), 132-143. doi: 10.1177/1545968311421614

Dunnett, S. B., & Björklund, A. (1999). Prospects for new restorative and neuroprotective treatments in Parkinson's disease. *Nature*, *399*, A32-A39.

Earhart, G. M. (2010). Dance as a therapy for those with Parkinson disease. *European Journal Physical Rehabilitation Medicaticine.*, 45 (2), 231-238.

Ehringer, H., & Hornykiewicz, O. (1960). Distribution of noradrenaline and dopamine (3-hydroxytyramine) in the human brain and their behavior in diseases of the extrapyramidal system. *Klinische Wochenschrift*, *38*, 1236.

Eyigor, S., Karapolat, H., Durmaz, B., Ibisoglu, U., & Cakir, S. (2009). A randomized controlled trial of Turkish folklore dance on the physical performance, balance, depression and quality of life in older women. *Archives Of Gerontology and Geriatrics,* 48(1), 84-88.

Fahn S, & Elton R L. (1987). Unified Parkinson's disease rating scale. In M. C. Fahn S, Goldstein M, Calne DB, (Ed.), *Recent developments in Parkinson's disease*. (pp. 153-163). New York: McMillan.

Fahn, S., Oakes, D., Shoulson, I., Kieburtz, K., Rudolph, A., Lang, A., ... & Marek, K. (2004). Levodopa and the progression of Parkinson's disease. *The New England Journal of Medicine*, *351*(24), 2498-2508.

Falvo, M. J., & Earhart, G. M. (2009). Six-minute walk distance in persons with Parkinson disease: a hierarchical regression model. *Archives of Physical Medicine and Rehabilitation*, *90*(6), 1004-1008.

Fisher, B. E., Li, Q., Nacca, A., Salem, G. J., Song, J., Yip, J., ... & Petzinger, G. M. (2013). Treadmill exercise elevates striatal dopamine D2 receptor binding potential in patients with early Parkinson's disease. *Neuroreport*, *24*(10), 509-514.

Field, A. P., & Gillett, R. (2010). How to do a meta‐analysis. *British Journal of Mathematical and Statistical Psychology,* 63(3), 665-694.

Foster, E. R., Bedekar, M., & Tickle-Degnen, L. (2014). Systematic review of the effectiveness of occupational therapy–related interventions for people with Parkinson's disease. *American Journal of Occupational Therapy*, 68(1), 39-49.

Foster, E. R., Golden, L., Duncan, R. P., & Earhart, G. M. (2012). A community-based Argentine tango dance program is associated with increased activity participation among individuals with Parkinson disease. *Archives of Physical Medicine and Rehabilitation.* Archives of physical medicine and rehabilitation 94.2 (2013): 240-249.

Gao and Hong (2011) Gene-environment interactions: key to unravelling the mystery of Parkinson's Disease, *Progress in Neurobiology,* 94:1-19

Garber, C. E., & Friedman, J. H. (2003). Effects of fatigue on physical activity and function in patients with Parkinson's disease. *Neurology*, *60*(7), 1119-1124.

Gerecke, K. M., Jiao, Y., Pani, A., Pagala, V., & Smeyne, R. J. (2010). Exercise protects against MPTP-induced neurotoxicity in mice. *Brain Research*, *1341*, 72-83.

Giladi, N., Shabtai, H., Simon, E., Biran, S., Tal, J., & Korczyn, A. (2000). Construction of freezing of gait questionnaire for patients with Parkinsonism. *Parkinsonism & Related Disorders*, 6(3), 165-170.

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

Goodwin, V. A., Richards, S. H., Taylor, R. S., Taylor, A. H., & Campbell, J. L. (2008). The effectiveness of exercise interventions for people with Parkinson's disease: A systematic review and meta-analysis. *Movement Disorders*, 23(5), 631-640. doi: 10.1002/mds.21922

Golden, J., Conroy, R. M., Bruce, I., Denihan, A., Greene, E., Kirby, M., & Lawlor, B. A. (2009). Loneliness, social support networks, mood and wellbeing in community-dwelling elderly. *InternationalJjournal of Geriatric Psychiatry*, *24*(7), 694-700.

Goldstein, D., Imrich, R., Peckham, E., Holmes, C., Lopez, G., Crews, C., . . . Hallett, M. (2007). Neurocirculatory and nigrostriatal abnormalities in Parkinson disease from LRRK2 mutation. *Neurology,* 69(16), 1580-1584.

Goff, K., & Torrence, E. P. (2002). *The Abbreviated Torrence Test for Adults (ATTA).* Bensenville, IL: Scholastic Testing Service.

Gotham, A., Brown, R., & Marsden, C. (1986). Depression in Parkinson's disease: a quantitative and qualitative analysis. *Journal of Neurology, Neurosurgery & Psychiatry*, 49(4), 381-389.

Guilford, J. P. (1967). The nature of human intellegence. New York: McGraw-Hill.

Grahn, J. A. (2009). The role of the basal ganglia in beat perception. *Annals of the New York Academy of Sciences,* 1169(1), 35-45.

Grahn, J. A., & Brett, M. (2007). Rhythm and beat perception in motor areas of the brain. *Journal of Cognitive Neuroscience*, 19(5), 893-906.

Grahn, J. A., & Brett, M. (2009). Impairment of beat-based rhythm discrimination in Parkinson's disease. *Cortex*, 45(1), 54-61.

Grahn, J. A., Parkinson, J. A., & Owen, A. M. (2008). The cognitive functions of the caudate nucleus. *Progress in Neurobiology*, 86(3), 141-155.

Grahn, J. A., Parkinson, J. A., & Owen, A. M. (2009). The role of the basal ganglia in learning and memory: neuropsychological studies. *Behavioural Brain Research*, 199(1), 53-60.

Grundy, E., & Sloggett, A. (2003). Health inequalities in the older population: the role of personal capital, social resources and socio-economic circumstances. *Social Science & Medicine*, 56(5), 935-947.

Guehl, D., Pessiglione, M., Francois, C., Yelnik, J., Hirsch, E., Feger, J., & Tremblay, L. (2003). Tremor related activity of neurons in the motor thalamus: changes in firing rate and pattern in the MPTP vervet model of parkinsonism. *European Journal of Neuroscience,* 17(11), 2388-2400.

Hackney, M. E., Kantorovich, S. B. S., Levin, R. D. P. T., & Earhart, G. M. (2007). Effects of tango on functional mobility in Parkinson's disease: A preliminary Study. *Journal of Neurologic Physical Therapy*, 31(4), 173-179.

Hackney, M. E., Kantorovich, S., & Earhart, G. M. (2007). A Study on the Effects of Argentine Tango as a Form of Partnered Dance for those with Parkinson Disease and the Healthy Elderly. *American Journal of Dance Therapy*, 29(2), 109-127. doi: 10.1007/s10465-007-9039-2

Hackney, M. E., & Earhart, G. M. (2009a). Effects of dance on movement control in Parkinson's disease: A comparison of Argentine tango and American ballroom. *Journal of Rehabilitation Medicine*, 41(6), 475-481. doi: 10.2340/16501977-0362

Hackney, M. E., & Earhart, G. M. (2009b). Short duration, intensive tango dancing for Parkinson disease: An uncontrolled pilot study. *Complementary Therapies in Medicine,* 17(4), 203-207. doi: 10.1016/j.ctim.2008.10.005

Hackney, M. E., & Earhart, G. M. (2009c). Health-related quality of life and alternative forms of exercise in Parkinson disease. *Parkinsonism & Related Disorders,* 15(9), 644-648. doi: 10.1016/j.parkreldis.2009.03.003

Hackney, M. E., & Earhart, G. M. (2009d). Effects of dance on gait and balance in Parkinson's disease: a comparison of partnered and nonpartnered dance movement. *Neurorehabilitation and neural repair*. 24(4): 384–392.

Hackney, M. E., & Earhart, G. M. (2010). Effects of dance on balance and gait in severe Parkinson disease: a case study. *Disability and rehabilitation*, *32*(8), 679-684.

Hackney, M. E., & Earhart, G. M. (2010b). Recommendations for implementing tango classes for persons with Parkinson disease. *American Journal of Dance Therapy*, *32*(1), 41-52.

Hackney, M., & Bennett, C. (2014). Dance therapy for individuals with Parkinson's disease: improving quality of life. *Journal of Parkinsonism and Restless Legs Syndrome,* 4, 17-25.

Halliday G et al.(2011) Milestones in Parkinson's Disease – Clinical and Pathological Features, *Movement Disorders,* 26(6):1015-1021

Hanakawa, T., Katsumi, Y., Fukuyama, H., Honda, M., Hayashi, T., Kimura, J., & Shibasaki, H. (1999). Mechanisms underlying gait disturbance in Parkinson's disease A single photon emission computed tomography study. *Brain*, 122(7), 1271-1282.

Hansen, C. J., Stevens, L. C., & Coast, J. R. (2001). Exercise duration and mood state: how much is enough to feel better? *Health Psychology*, 20(4), 267.

Hashimoto, H., Takabatake, S., Miyaguchi, H., Nakanishi, H., & Naitou, Y. (2015). Effects of dance on motor functions, cognitive functions, and mental symptoms of Parkinson's disease: A quasi-randomized pilot trial. *Complementary Therapies in Medicine,* 23(2), 210-219.

Heiberger, L. (2011). Impact of a weekly dance class on the functional mobility and on the quality of life of individuals with parkinson's disease. *Frontiers in Aging Neuroscience,* 3. doi: 10.3389/fnagi.2011.00014

Herman, T., Giladi, N., & Hausdorff, J. M. (2008). Treadmill training for the treatment of gait disturbances in people with Parkinson's disease: a mini-review. *Journal of Neural Transmission*, 116(3), 307-318. doi: 10.1007/s00702-008-0139-z

Hill, K. D., Schwarz, J. A., Kalogeropoulos, A. J., & Gibson, S. J. (1996). Fear of falling revisited. *Archives of Physical Medicine and Rehabilitation*, 77(10), 1025-1029.

Hoehn, M. M., & Yahr, M. D. (1967). Parkinsonism: onset, progression, and mortalilty. *Neurology*, 17(5), 427-442.

Honing, H. (2012). Without it no music: beat induction as a fundamental musical trait. *Annals of the New York Academy of Sciences*, 1252(1), 85-91.

Hornykiewicz, O. (1966). Dopamine (3-hydroxytyramine) and brain function. *Pharmacological Reviews*, *18*(2), 925-964.

Houston, S., & McGill, A. (2013). A mixed-methods study into ballet for people living with Parkinson's. *Arts & Health*, 5(2), 103-119.

Huang, S. L., Hsieh, C. L., Wu, R. M., Tai, C.., Lin, C.., & Lu,. S. (2010). Minimal Detectable Change of the Timed "Up & Go" Test and the Dynamic Gait Index in People With Parkinson Disease. *Physical Therapy,* 91(1), 114-121. doi: 10.2522/ptj.20090126

Hui, E., Chui, B. T.-k., & Woo, J. (2009). Effects of dance on physical and psychological well-being in older persons. *Archives Of Gerontology and Geriatrics*, 49(1), e45-e50. doi: 10.1016/j.archger.2008.08.006

Hurley, M. J., Mash, D. C., & Jenner, P. (2003). Markers for dopaminergic neurotransmission in the cerebellum in normal individuals and patients with Parkinson's disease examined by RT - PCR. *European Journal of Neuroscience,* 18(9), 2668-2672.

Jette, M., Sidney, K., & Blümchen, G. (1990). Metabolic equivalents (METS) in exercise testing, exercise prescription, and evaluation of functional capacity. *Clinical Cardiology*, *13*(8), 555-565.

Karpati, F. J., Giacosa, C., Foster, N. E., Penhune, V. B., & Hyde, K. L. (2015). Dance and the brain: a review. *Annals of the New York Academy of Sciences*, *1337*(1), 140-146.

Kattenstroth. (2010). Superior sensory, motor, and cognitive performance in elderly individuals with multi-year dancing activities. *Frontiers in Aging Neuroscience*. doi: 10.3389/fnagi.2010.00031

Kennedy, M., & Newton, M. (1997). Effect of exercise intensity on mood in step aerobics. *The Journal of sports medicine and physical fitness*, 37(3), 200-204.

Kim, S., & Kim, J. (2007). Mood after various brief exercise and sport modes: aerobics, hip hop dancing, ice skating, and body conditioning 1. *Perceptual and Motor Skills*, *104*(3c), 1265-1270.

King, L. A., Priest, K. C., Salarian, A., Pierce, D., & Horak, F. B. (2011). Comparing the Mini-BESTest with the Berg Balance Scale to evaluate balance disorders in Parkinson's disease. *Parkinson's Disease*, 2012.

Koch, S. C., Morlinghaus, K., & Fuchs, T. (2007). The joy dance: Specific effects of a single dance intervention on psychiatric patients with depression. *The Arts in Psychotherapy,* 34(4), 340-349.

Koch, S., Kunz, T., Lykou, S., & Cruz, R. (2014). Effects of dance movement therapy and dance on health-related psychological outcomes: A meta-analysis. *The Arts in Psychotherapy,* 41(1), 46-64.

Koerts, J., Leenders, K. L., & Brouwer, W. H. (2009). Cognitive dysfunction in non-demented Parkinson's disease patients: controlled and automatic behavior. *Cortex,* 45(8), 922-929.

Krause, N., & Jay, G. (1991). Stress, Social Support and Negative Interaction in Older Life. *Research on Aging, 13*, 333-363.

Lane, A. M., & Lovejoy, D. J. (2001). The effects of exercise on mood changes: the moderating effect of depressed mood. *Journal of Sports Medicine and Physical Fitness*, 41(4), 539-545.

Lawton, M. P. (1975). The Philadelphia geriatric center morale scale: A revision. *Journal of Gerontology*, 30(1), 85-89.

Lee, N.-Y., Lee, D.-K., & Song, H.-S. (2015). Effect of virtual reality dance exercise on the balance, activities of daily living, and depressive disorder status of Parkinson's disease patients*. Journal of Physical Therapy Science*, 27(1), 145.

Lees, A. J., Hardy, J., & Revesz, T. (2009). Parkinson's disease. *The Lancet. 9680* (373) 2055-2066

Lennox, S. S., Bedell, J. R., & Stone, A. A. (1990). The effect of exercise on normal mood. *Journal of Psychosomatic Research*, 34(6), 629-636.

Lertiz, E., Loftis, C., Crician, G., Friedman, W., & Bowers, D. (2004). Self-Awareness of Deficits in Parkinson's Disease. *The Clinical Neuropsychologist*, 18, 352-361.

Lewis, C., & Lovatt, P. (2013). Breaking away from set patterns of thinking: Improvisation and Divergent thinking. *Thinking Skills and Creativity.*

Lewis, C., Annett, L. E., Davenport, S., Hall, A. A., & Lovatt, P. (2014). Mood changes following social dance sessions in people with Parkinson's disease. *Journal of Health Psychology*, 1359105314529681.

Lotharius, J., & Brundin, P. (2002). Pathogenesis of Parkinson's disease: dopamine, vesicles and alpha-synuclein. *Nature Reviews Neuroscience*, 3(12), 932-942.

Lötzke, D., Ostermann, T., & Büssing, A. (2015). Argentine tango in Parkinson disease–a systematic review and meta-analysis. *BMC neurology*, *15*(1), 226.

Maher, C. G., Sherrington, C., Herbert, R. D., Moseley, A. M., & Elkins, M. (2003). Reliability of the PEDro scale for rating quality of randomized controlled trials. *Physical Therapy*, 83(8), 713-721.

Mandelbaum, R., & Lo, A. C. (2014). Examining dance as an intervention in Parkinson's disease: a systematic review. *American Journal of Dance Therapy*, 36(2), 160-175.

Marchant, D., Sylvester, J., & Earhart, G. M. (2010). Effect of a short duration, high dose contact improvisation dance workshop on Parkinson disease: A pilot study. *Complementary Therapies in Medicine*, 18, pp.184-190.

Mathias, S., Nayak, U., & Isaacs, B. (1986). Balance in elderly patients: the" get-up and go" test. *Archives of Physical Medicine and Rehabilitation*, 67(6), 387-389.

Maxwell, S. (2001). When to Use MANOVA and Significant MANOVAs and Insignificant ANOVAs or Vice Versa. Journal of Consumer Psychology, 10(1/2), *Methodological and Statistical Concerns of the Experimental Behavioral Researcher* 10, 29-30.

McAuley, J. D., Jones, M. R., Holub, S., Johnston, H. M., & Miller, N. S. (2006). The time of our lives: life span development of timing and event tracking. *Journal of Experimental Psychology: General*, 135(3), 348.

McDermott, J., & Hauser, M. (2005). The origins of music: Innateness, uniqueness, and evolution. *Music Perception*, 23(1), 29-59.

McGill, A., Houston, S., & Lee, R. Y. (2014). Dance for Parkinson's: A new framework for research on its physical, mental, emotional, and social benefits. *Complementary Therapies in Medicine*, 22(3), 426-432.

McIntosh, G. C., Brown, S. H., Rice, R. R., & Thaut, M. H. (1997). Rhythmic auditory-motor facilitation of gait patterns in patients with Parkinson's disease. *Journal of Neurology, Neurosurgery & Psychiatry*, 62(1), 22-26.

McKee, K. E., & Hackney, M. E. (2013). The effects of adapted tango on spatial cognition and disease severity in Parkinson's disease. *Journal of Motor Behavior,* 45(6), 519-529.

McInman, A. D., & Berger, B. G. (1993). Self‐concept and mood changes associated with aerobic dance. *Australian Journal of Psychology*, 45(3), 134-140.

McNair, D. M., Droppleman, L. F., & Lorr, M. (1992). Edits manual for the profile of mood states: POMS: Edits.

McNeely, M., Duncan, R., & Earhart, G. (2015). A comparison of dance interventions in people with Parkinson disease and older adults. *Maturitas,* 81(1), 10-16.

Miranda, D., Morizot, J., & Gaudreau, P. (2010). Personality Metatraits and Music Preferences in Adolescence: A Pilot Study. *International Journal of Adolescence and Youth*, *15*(4), 289-301.

Natbony, L. R., Zimmer, A., Ivanco, L. S., Studenski, S. A., & Jain, S. (2013). Perceptions of a Vvdeogame-based dance exercise program among individuals with Parkinson's disease. *Games for Health: Research, Development, and Clinical Applications,* 2(4), 235-239.

Netz, Y., Wu, M.-J., Becker, B. J., & Tenenbaum, G. (2005). Physical activity and psychological well-being in advanced age: a meta-analysis of intervention studies. *Psychology and Aging*, 20(2), 272.

Nieuwboer, A., Kwakkel, G., Rochester, L., Jones, D., van Wegen, E., Willems, A. M., . . . Lim, I. (2007). Cueing training in the home improves gait-related mobility in Parkinson's disease: the RESCUE trial. *Journal of Neurology, Neurosurgery & Psychiatry,* 78(2), 134-140.

North, A. C., Hargreaves, D. J., & O'Neill, S. A. (2000). The importance of music to adolescents. *British Journal of Educational Psychology*, *70*, 255.

Nussbaum, P. D. (1997). *Handbook of Neuropsychology and Aging*. New York: Plenum Press.

Pacchetti, C., Mancini, F., Aglieri, R., Fundaro, C., Martignoni, E., & Nappi, G. (2000). Active music therapy in Parkinson,'s disease: an integrative method for motor and emotional rehabilitation. *Psychosomatic medicine*, 62(3), 386-393.

Penhune, V. B., Zatorre, R. J., & Evans, A. C. (1998). Cerebellar contributions to motor timing: a PET study of auditory and visual rhythm reproduction. Journal of *Cognitive Neuroscience*, 10(6), 752-765.

Peto, V., Jenkinson, C., & Fitzpatrick, R. (1998). Parkinson's diseaseQ-39: a review of the development, validation and application of a Parkinson's disease quality of life questionnaire and its associated measures. *Journal of Neurology*, 245(1), S10-S14.

Piccini, P., Brooks, D. J., Björklund, A., Gunn, R. N., Grasby, P. M., Rimoldi, O., ... & Lindvall, O. (1999). Dopamine release from nigral transplants visualized in vivo in a Parkinson's patient. *Nature Neuroscience*, *2*(12), 1137-1140.

Plante, T. G., Aldridge, A., Bogden, R., & Hanelin, C. (2003). Might virtual reality promote the mood benefits of exercise? *Computers in Human Behavior*, 19, 495–509.

Powell, L. E., & Myers, A. M. (1995). The Activities-specific Balance Confidence (ABC) Scale. Journal of Gerontology: *Medical Sciences*, 50(1), M28-M34.

Podsiadlo, D. & Richardson, S. (1991). The Timed 'Up and Go' test: a test of basic functional mobility for frail elderly adults. *Journal of American Geriatric Association, 39,* 142-148.

Remy, P., Doder, M., Lees, A., Turjanski, N., & Brooks, D. (2005). Depression in Parkinson's disease: loss of dopamine and noradrenaline innervation in the limbic system. *Brain*, 128(6), 1314-1322.

Repp, B. H. (2005). Sensorimotor synchronization: a review of the tapping literature. *Psychonomic bulletin & review*, 12(6), 969-992.

Repp, B. H., & Su, Y.-H. (2013). Sensorimotor synchronization: A review of recent research (2006 - 2012). *Psychonomic Bulletin & Review*, 20(3), 403-452.

Rigg, M. G. (1964). The mood effects of music: A comparison of data from four investigators. *The Journal of Psychology*, 58(2), 427-438.

Roberts, B. L., Dunkle, R., & Haug, M. (1994). Physical, psychological, and social resources as moderators of the relationship of stress to mental health of the very old. *Journal of Gerontology*, 49(1), S35-S43.

Robinson, F. R. (1995). Role of the cerebellum in movement control and adaptation. *Current Opinion in Neurobiology*, *5*(6), 755-762.

Rolland, A.-S., Herrero, M.-T., Garcia-Martinez, V., Ruberg, M., Hirsch, E. C., & Francois, C. (2007). Metabolic activity of cerebellar and basal ganglia-thalamic neurons is reduced in Parkinsonism. *Brain*, 130(1), 265-275.

Romenets, S. R., Anang, J., Fereshtehnejad, S.-M., Pelletier, A., & Postuma, R. (2015). Tango for treatment of motor and non-motor manifestations in Parkinson's disease: A randomized control study. *Complementary Therapies in Medicine,* 23(2), 175-184.

Reuter, M., Roth, S., Holve, K., & Hennig, J. (2006). Identification of first candidate genes for creativity: a pilot study. *Brain Research*, 1069(1), 190-197.

Rosnow, R. L., & Rosenthal, R. (1996). Computing contrasts, effect sizes, and counternulls on other people's published data: General procedures for research consumers. *Psychological Methods*, 1(4), 331.

Sacrey, L.-A. R., Clark, C. A., & Whishaw, I. Q. (2009). Music attenuates excessive visual guidance of skilled reaching in advanced but not mild Parkinson's disease. *PloS One,* 4(8), e6841.

Sarason, I. G., Levine, H. M., Basham, R. B., & Sarason, B. R. (1983). Assessing social support: The social support questionnaire. *Journal of personality and social psychology*, 44(1), 127.

Särkämö, T., Pihko, E., Laitinen, S., Forsblom, A., Soinila, S., Mikkonen, M., . . . Laine, M. (2010). Music and speech listening enhance the recovery of early sensory processing after stroke. *Journal of Cognitive Neuroscience*, 22(12), 2716-2727.

Schmitz‐Hübsch, T., Pyfer, D., Kielwein, K., Fimmers, R., Klockgether, T., & Wüllner, U. (2006). Qigong exercise for the symptoms of Parkinson's disease: a randomized, controlled pilot study. *Movement Disorders*, 21(4), 543-548.

Schreurs, K. M., De Ridder, D. T., & Bensing, J. M. (2000). A one year study of coping, social support and quality of life in Parkinson's disease. *Psychology and Health,* 15(1), 109-121.

Schwartz, M., Keller, P. E., Patel, A. D., & Kotz, S. A. (2011). The impact of basal ganglia lesions on sensorimotor synchronization, spontaneous motor tempo, and the detection of tempo changes. *Behavioural Brain Research*, 216(2), 685-691.

Shepard, R. N., & Metzler, J. (1971). Mental Rotation of Three Dimensional Objects. *Science,* 171(3972), 701-703.

Shanahan, J., Morris, M. E., Bhriain, O. N., Saunders, J., & Clifford, A. M. (2015). Dance for people with Parkinson disease: what is the evidence telling us? *Archives of Physical Medicine and Rehabilitation,* 96(1), 141-153.

Sharp, K., & Hewitt, J. (2014). Dance as an intervention for people with Parkinson's disease: a systematic review and meta-analysis. *Neuroscience & Biobehavioral Reviews,* 47, 445-456.

Sheikh, J. I., & Yesavage, J. A. (1986). Geriatric Depression Scale (GDS): recent evidence and development of a shorter version. *Clinical Gerontologist: The Journal of Aging and Mental Health.*

Shulman, L., Taback, R., Rabinstein, A., & Weiner, W. (2002). Non-recognition of depression and other non-motor symptoms in Parkinson's disease. *Parkinsonism & Related Disorders, 8*(3), 193-197.

Slaughter, J. R., Slaughter, K. A., Nichols, D., Holmes, S. E., & Martens, M. P. (2001). Prevalence, clinical manifestations, etiology, and treatment of depression in Parkinson's disease. *The Journal of neuropsychiatry and clinical neurosciences*, 13(2), 187-196.

Speer, D. C. (1993). Predicting Parkinson's Disease patient and caregiver adjustment: Preliminary findings. *Behavior, Health, & Aging*.

Steffen, T. M., Hacker, T. A., & Mollinger, L. (2002). Age-and gender-related test performance in community-dwelling elderly people: Six-Minute Walk Test, Berg Balance Scale, Timed Up & Go Test, and gait speeds. *Physical Therapy*, *82*(2), 128-137.

Steffen, T., & Seney, M. (2008). Test-retest reliability and minimal detectable change on balance and ambulation tests, the 36-item short-form health survey, and the unified Parkinson disease rating scale in people with Parkinsonism. *Physical Therapy*, 88(6), 733-746.

Steptoe, A., & Cox, S. (1988). Acute effects of aerobic exercise on mood. *Health Psychology,* 7(4), 329.

Sutoo, D. E., & Akiyama, K. (2004). Music improves dopaminergic neurotransmission: demonstration based on the effect of music on blood pressure regulation. *Brain Research*, 1016(2), 255-262.

Swartzberg, J. (2011). Sound body, sound mind. *University Of California At Berkeley Wellness Letter*, *27*(11), 3.

Tajiri, N., Yasuhara, T., Shingo, T., Kondo, A., Yuan, W., Kadota, T., . . . Morimoto, T. (2010). Exercise exerts neuroprotective effects on Parkinson's disease model of rats. *Brain research*, 1310, 200-207.

Terry, P. C., & Lane, A. (1993). User guide for he Brunel University Mood Scale (BRUMS). UK: University of Wolverhampton.

Terry, P. C., & Lane, A. M. (2000). Terry, P.C., & Lane, A.M (2000). *Journal of Applied Sports Psychology,* 17(11), 861-872.

Thaut, M., Kenyon, G., Schauer, M., & McIntosh, G. (1999). The connection between rhythmicity and brain function. *Engineering in Medicine and Biology Magazine, IEEE,* 18(2), 101-108.

Thaut, M., McIntosh, G., Rice, R., Miller, R., Rathbun, J., & Brault, J. (1996). Rhythmic auditory stimulation in gait training for Parkinson's disease patients. *Movement Disorders*, 11(2), 193-200.

Thomas, S., Reading, J., & Shephard, R. J. (1992). Revision of the Physical Activity Readiness Questionnaire (PAR-Q). *Canadian Journal of Sports Sciences*, 17(4), 338-345.

Tillerson, J. L., Cohen, A. D., Philhower, J., Miller, G. W., Zigmond, M. J., & Schallert, T. (2001). Forced limb-use effects on the behavioral and neurochemical effects of 6-hydroxydopamine. *The Journal of Neuroscience,21*(12), 4427-4435.

Tinetti, M., Richman, D., & Powell, L. E. (1990). Falls Efficacy as a Measure of Fear of Falling. *Journal of Gerontology*, 45, 239.

Tomlinson, C. L., Patel, S., Meek, C., Herd, C. P., Clarke, C. E., Stowe, R., . . . Wheatley, K. (2012). Physiotherapy intervention in Parkinson's disease: systematic review and meta-analysis. *British Medical Journal*, 345, e5004.

Vellas, B. J., Wayne, S. J., Romero, L., Baumgartner, R. N., Rubenstein, L. Z., & Garry, P. J. (1997). One-leg balance is an important predictor of injurious falls in older persons. *Journal of the American Geriatrics Society,* 45(6), 735-738.

Verhagen, A. P., de Vet, H. C., de Bie, R. A., Kessels, A. G., Boers, M., Bouter, L. M., & Knipschild, P. G. (1998). The Delphi list: a criteria list for quality assessment of randomized clinical trials for conducting systematic reviews developed by Delphi consensus. *Journal of Clinical Epidemiology*, *51*(12), 1235-1241.

Volpe, D., Signorini, M., Marchetto, A., Lynch, T., & Morris, M. E. (2013). A comparison of Irish set dancing and exercises for people with Parkinson's disease: A phase II feasibility study. *BMC geriatrics*, 13(1), 54.

Weintraub, D., Comella, C. L., & Horn, S. (2008). Parkinson's disease,part 1: pathophysiology, symptoms, burden, diagnosis, and assessment. *American Journal of Managing Care, 14*(2 Suppl), S40-S48.

Westheimer, O. M. A. (2008). Why Dance for Parkinson's Disease. *Topics in Geriatric Rehabilitation Parkinson's Disease April/June, 24*(2), 127-140.

Wu, T., & Hallett, M. (2013). The cerebellum in Parkinson's disease. *Brain, 136*(3), 696-709.

Zatorre, R. J., Chen, J. L., & Penhune, V. B. (2007). When the brain plays music: auditory motor interactions in music perception and production. *Nature Reviews Neuroscience, 8*(7), 547-558.

Zetusky, W. J., Jankovic, J., & Pirozzolo, F. J. (1985). The heterogeneity of Parkinson's disease Clinical and prognostic implications. *Neurology*, 35(4), 522-522.

Zigmond, M. J., & Smeyne, R. J. (2014). Exercise: is it a neuroprotective and if so, how does it work?. *Parkinsonism & Related Disorders*, *20*, S123-S127.

Appendix A

Braak Staging of Lewy Bodies in Parkinson's disease

Sensory Centres	Olfactory: early and severe involvement
	Nociceptive: early involvement
	Somatosensory: mostly intact
	Viscerosensory: mostly intact
	Auditory and Visual: ininvolved
Motor Centres	Visceromotor: early and severe involvement
	Somatomotor: partial involvement
	Limbic: severe involvement
Stage 1	Anterior olfactory nucleus
	Olfactory bulb, olfactory tract
	Dorsal motor nucleus of the vagal nerve
	Intermediate reticular zone
Stage 2	Lower raphe nuclei
	Magnocellular reticular nuclei
	Coeruleus-subcoeruleus complex
Stage 3	Cenreal subnucleus of the amygdala
	Olfactory tubercle, piriform cortex (olfactory system)
	Periamygdalear cortex (olfactory system)
	Medial entorhinal region (olfactory system)
	Substantia nigra, pars compacta
	Paranigral nucleus
	Edinger Westphal nucleus
	Pigmented parabrachial nucleus
	Upper raphe nuclei
	Tuberomamillary nucleus
	Magnocellular basal forebrain nuclei
	Pedunculopontine tegmental nucleus
Stage 4	Interstitial nucleus of the terminal stria
	Cortical and basolateral amygdala
	Thalamic intralaminar nuclei

	Thalamic midline nuclei
	Anteromedial temporal mesocortex
	Ammon's horn, second sector (CA3)
	Insular and subgenal cortex
	Ventral claustrum
Stage 5	High order sensory association neocortex
	Prefrontal neocortex
	Entorhinal region, CA1 & CA3 sectors
Stage 6	High order sensory association neocortex
	Premotor neocortex
	Primary sensory areas
	Primary motor field

Appendix B
Medication

There are six main types of medication that are currently used to treat the symptoms of Parkinson's disease. Including Levodopa, Dopamine Agonists, COMT inhibitors, MAO B inhibitors and Anticholinergics. Within each of these type of medication there are a number of different combinations and forms in which the drugs are administered. With all these medications, low doses are initially administered and are gradually increased in order to control symptoms (Parkinson's UK). Doses increase and other medications added as the disease advances and other symptoms appear. PD medication can also begin to become less effective with time. Patients may experience more frequent or longer 'Off" periods which may suggest that the drugs need to be increased or taken more regularly.

Due to the deficit of dopamine in the PD brain, people experience slowness of movement and coordination problems. PD medication works within the dopamine system by increasing dopamine levels (Levodopa) or stimulate the dopamine receptors, therefore bypassing the need to produce dopamine (Dopamine Agonists) to reduce the negative effect the symptoms have. It is worth noting that these medications predominantly target the motor symptoms of the disease, there are a number of non motor symptoms that require separate treatment (anxiety and depression for example).

Levodopa

Levodopa is the most effective medication to treat the symptoms of PD disease. Levodopa is the chemical precursor to dopamine and is converted to dopamine in the Basal Ganglia. This replaces the dopamine that is lost in PD disease, therefore increasing the levels of dopamine and improving motor symptoms. Once taken, L-Dopa is broken down by the enzyme DOPA decarboxylase in the central nervous system. L-Dopa on its own causes vomiting and therefore is combined with Carbidopa to prevent nausea.

Levodopa is most effective for improving movement, decreasing rigidity and decreasing tremor (Fahn et al. 2004). Unlike some of the other medications, Levodopa can be used to treat all stages of the disease, however, it is commonly used in older patients as its effects do wear off over long term use. It does not slow down disease progression, but does however improve movement having an effect on the individuals quality of life.

Levodopa is the most common and effective treatment, and can alleviate symptoms to a point by increasing levels of dopamine. Levodopa is not however, a cure and can have a number of side effects. Most commonly Levodopa produces dyskinesia's when used long term. There may also be some cognitive side effects of this drug, including delusional thinking and hallucinations, however these side effects are less severe than in Dopamine Agonists.

Dopamine Agonists:

Dopamine Agonists are the second most common treatment for PD disease. Unlike Levodopa, Dopamine Agonists are not converted in Dopamine, but stimulate the dopamine receptors in order for the brain to believe it is being given the Dopamine it requires. This imitates the effect of Dopamine at these receptors leading to improved movement. Dopamine agonists are often prescribed for individuals that are in the early stages of the disease or relatively young, however this medication can be used at all stages. Dopamine Agonists can delay the prescription of Levodopa (as it only has a 5-10 year window of improving symptoms). Dopamine Agonists can also be used in conjunction with Levodopa when the effectiveness of Levodopa begins to fail (Brooks, 2000).

Dopamine Agonists are most effective in reducing 'Off' time, improving motor function and allowing lower doses of Levodopa to be prescribed. Dopamine Agonists are not very effective in treating Tremor.

There are some major side effects associated with Dopamine Agonists, both physically and cognitively. Physical side effects are less prominent than Levodopa, with Dyskinesia less likely. A gradual decrease in dosage is required

when stopping this medication as withdrawl symptoms can occur. Cognitive side effects, however, are more common when taking Dopamine Agonists. These include hallucinations, delhusions and confusion. Rasacole et al.(2000) found that when comparing Ropinerole (a commonly prescribed Dopamine Agonist) with Levodopa, 17.3% had hallucinations compared with 5.6% taking Levodopa. This trend was also observed when measuring Somnolence (drowsiness), with 27.4% of those taking Ropinerole and 19% taking Levodopa. This was supported by Holloway et al.(2004) that found 42% of those taking Pramipexole (another common Dopamine Agonist) were experiencing hallucinations compared with 15% taking Levodopa.   This again was echoed in somnolence with 36% taking Pramiprexole experiencing drowsiness compared with 21% of those using Levodopa.   Grosset, Macphee, Pal, Stewart, Watt, Davey and Grosset (2006)have also suggested that Dopamine Agonists can cause impulse control disorders such as gambling and binge eating.

Catecholomethyl Transferase inhibitors (COMT) inhibitors:
COMT inhibitors are used to bock the enzyme Catecholomethyl Transferase from breaking down dopamine. This form of medication is always taken with Levodopa. COMT inhibitors are mainly used to help with 'wearing off' associated with Levodopa treatments. COMT inhibitors help to deliver more Levodopa and prolong the effect in the brain. Stalevo (a form of Levdopa) includes entacapone (which is a form of COMT inhibitor) within it.

COMT inhibitors are most effective in reducing motor fluctuations seen in those taking Levodopa. This medication has a lower risk of cognitive and physical side effects, although one form of COMT inhibitor (Tolcapone) is associated with Liver injurys and therefore those taking this medication are required to have regular liver function tests. As this medication is increasing the level of Levodopa present in the brain, the main side effect of COMT inhibitors are Levodopa based (Dyskinesias etc).

Selective Monoamine Oxidase (MAO B) inhibitors:

MAO B inhibitors work by inhibiting Monoamine Oxidase which is an enzyme that breaks down dopamine in the brain. This means Dopamine can stay in an inactive state in the brain for longer (Parkinson's UK). MAO B inhibitors can be used alone, in the early stages of PD or with Levodopa for those experiencing motor fluctuations. There are two forms of MAO B inhibitor, Selegeline and Rasageline. Selegeline is most commonly used in combination with Levodopa to reduce 'Off' periods, wheras Rasageline is more commonly used alone in the early stages of PD.

MAO B inhibitors are most commonly used to decrease motor fluctuations. This medication can be said to have a modest effect on the motor symptoms of PD and may have a slight antidepressant quality.

Physical side effects can include pain and increased Dyskinesias (this is most likely when using in combination with Levodopa).   There is a low risk of cognitive side effects with MAO B inbitors (Lecht, Haroutiunian, Hoffman & Lazarovici, 2007). Selegiline metabolises to Amphetamine and therefore there may be side effects associated with this.

Anticholinergics:

Anticholinergics are the oldest medications used to treat PD. They work by blocking the neurotransmitter Acetycloline. Acetycholine and Dopamine are carefully balanced in those without PD, Anticholinergics reduce the level of Acetycholoine to ensure a closer balance between these two chemicals. Anticholinergics can be used alone to delay the need for Levodopa. This medication can also be used in conjunction with Levodopa or Glutamate Agonists as it prolongs the action of Dopamine.

Anticholinergics are used to treat Tremor and can help reduce 'wearing Off'. They are not very effective with the other symptoms of PD and would not be suitable for advanced PD. This medication is beneficial for around 50% of those with Tremor.

Cognitive side effects when using this medication are common, these include confusion, forgetfulness, hallucinations and can even cause a loss of Short Term Memory. Anticholinergics should not be prescribed for those over 70 years old that are more susceptible to these cognitive impairments.

Glutamate Antagonists:

There is only one Glutamate antagonist that has been used in the treatment of PD, Amantadine. This medication works by blocking the neurotransmitter Glutamate and stimulates the production of Dopamine. This treatment is not commonly used as it has a mild effect on the symptoms that does not last long. Amamtadine may be used in conjunction with other PD medications.

Above are the main pharmacological treatments associated with PD disease. Levodopa and Dopamine Agonists are the most common form of treatment, however other medications may be used alongside these or alone in the early stages of the disease. As with all these medications, they can improve symptoms of PD however a number of these have quite substantial side effects and are only effective for so long. With the nature of this disease, 80% of the dopamine producing neurones are already dead by the time symptoms present. These deplete even farther and the disease advances causing the medication to become less effective

Table. A1. Levodopa Medication

Type of Medication	Pharmaceutical name	Dosage	Usage
Co-Careldopa (Carbidopa/ Levodopa)	Sinemet	Low: 200mg/day Med: 500mg/day High: 800+mg/day	Common
	Half Sinamet		
	Sinamet Plus		
	Parcopa		
	Lecado		
	Duodopa (intestinal gel)		Uncommon
Co-Careldopa controlled release	Sinemet CR	Low: 200mg/day Med: 500mg/day High: 800+mg/day	Common
Co-Careldopa plus Entacapone (COMT inhibitor)	Stalevo	Low: 200mg/day Med: 500mg/day High: 800+mg/day	Common
Co-Beneldopa (Benserazide hydrochloride/Levodopa)	Madopar	Low: 200mg/day Med: 300mg/day High: 600+mg/day	Common

Table A2. Dopamine Agonist Medication

Type of Medication	Pharmaceutical name	Dosage	Usage
Apomorphine	APO-GO	Low: 10mg/day Med: 40mg/day High: 80mg/day	uncommon
Bromocriptine	Parlodel	Low: 2.5mg/day Med: 30mg/day High: 90mg/day	uncommon
Pramiprexole	Mirapex Mirapex CR	Low:0.5/day Med:2mg/day High:5mg/day	Common
Cabergoline	Cabaser Domperidone	Low: 0.5mg/day Med: 2mg/day High: 5mg/day	uncommon
Ropinerole	ReQuip	Low:0.75mg/day Med: 12mg/day High:24mg/day	Common
	Adartrel Spirico Ralnea	Low:0.25mg/day Med:2mg/day High:4mg/day	uncommon
Rotigotine	Neupro (patch)	Low: 2mg/day Med: 4mg/day High: 8mg/day	Common

Table A3. COMT Medication

Type of Medication	Pharmaceutical name	Dosage	Usage
Entacaone	Comtess	Low:200mg/day Med:400mg/day High:800mg/day	Common
Tolcapone	Tasmar	Low:100mg/day Med:200mg/day High:300mg/day	Uncommon due to liver injury

Table A4. MAO B Medication

Type of Medication	Pharmaceutical name	Dosage	Usage
Selegiline	Eldepryl	Low:5mg/day High:10mg/day	Common
	Zelapar	1.25mg/day	
Rasagiline	Azilect	Low:0.5mg/day High:1mg/day	Common

Table A5. Anticholinergic Medication

Type of Medication	Pharmaceutical name	Dosage	Usage
Orphenadrine	Biorphen	Low:0.5mg/day Med:3mg/day High:6mg/day	Uncommon
	Dispal		
Procyclidine	Arpicolin	Low:0.5mg/day Med:3mg/day High:6mg/day	Uncommon
	Kemadrin		
Trihexypendyl	Broflex	Low:1mg/day Med:8mg/day High:15mg/day	Uncommon

Table A6. Glutamate Antagonist Medication

Type of Medication	Pharmaceutical name	Dosage	Usage
Amantadine	Symmetrel	Low:100mg/day Med:300mg/day High:400mg/day	Uncommon

- Data normally distributed. This is assessed by each variable having a skewness statistic lower than ±1. Each variable is assessed by this rule before ANOVA are conducted. As the sample size is less than 30 the assumption of normality was not satisfied by the Central Limit Theorem. Therefore, variables containing skewed data will be analysed using the nonparametric Wilcoxon test that does not require normality of data.
- The Dependent variable is interval or ratio
- There is an Independent variable in which participants are tested on a dependent variable a minimum of two times.

Assumptions of repeated measures MANOVA
- Data normally distributed. This is assessed by each variable having a skewness statistic lower than ±1. Each variable is assessed by this rule before ANOVA are conducted.
- The Dependent variable is interval or ratio
- There is an Independent variable in which participants are tested on a dependent variable a minimum of two times.
- Spericity (Compound Symmetry) which ensures homogeneity of variances and covariances. To test this assumption, Mauchly's Test of Sphericity is required to be >.05. Before analysis, spericity was assessed using this technique.

Assumptions of ANCOVA
- Data normally distributed. This is assessed by each variable having a skewness statistic lower than ±1. However, as this analysis has >20 cases the ANCOVA is rhobust to violations of this assumption (central limit theorem)
- Homegenity of Variances
- The dependent variable is interval or ratio
- Independence of the covariate

- Homogenity of regression slopes. This investigates the interaction between the covariate and the IV. If this assumption is violated, ANCOVA should not be conducted.

Assumptions of repeated measures MANOVA
- **Normality of DV's** – assessed by skewness statistic and analysis of outliers and extreme cases.
- **Homogeneity of the covariance matrices –** assessed by the Box M test
- **Independence of observations –** data from the DV's should not be related to other participants in that condition. Correlations will be assessed to ensure it is appropriate to continue with MANOVA, a correlation of between .3 and .7 (Maxwell, 2001) is appropriate for this statistical test. It would not be appropriate to continue if DV's are correlated above .85.
- MANOVA and ANOVA can be quite robust to assumption violations, however as the sample size in the current study is small, adhering to statistical assumptions is vital. In all cases, the above assumptions have been tested, any violations are discussed during statistical reporting.

Semi structured interview schedule

Name……………………………………………………

Participant ID……………………………………………

Firstly I would like to say thank you for taking part in this Parkinson's Trial- hopefully it will bring us closer to understanding more about the disease and how dance can affect Parkinson's.

With your consent, the interview will be recorded on a recording device. The voice recorder will be visible to you at all times and the recording will only be reviewed by me and members of the research team in strict confidentiality. [Wait for consent]

If at any time you feel uncomfortable or do not wish to answer a particular question, you are not obliged to do so. If you want to stop the interview you may do so and without having to explain why.

All information you give will be kept confidential. Your identity will remain confidential to the extent provided by the law.

There are no direct risks to you by participating in this interview.

This interview will last 10-15 minutes and it is a space for you to tell me anything and everything you thought about the dance classes- good or bad!

Thoughts on the dance class
1) How did you find the dance classes? / What did you think of the dance classes?
2) What did you like about the classes?
3) What aspects of the classes did you dislike?

Impact of dance
4) Has the dance had an impact on you physically- either positively or negatively or not at all? Could you tell me a bit more about that? In what areas has the dance had an impact? E.g. around the house, getting to places

5a) How long do the effects you have described last?

5b) When did you first become aware of the effects?

5c) Have the dance classes affected your mood? In what ways?

Home life

6) Did you practise the dance steps at home after the dance classes?

7) Did anything affect or prevent you from coming to classes?

Expectations

8) Were the classes what you expected?

9) Where there any particular movements or dances you liked or disliked?

Previous experience of dance

10) Have you done any dance in the past? How does this compare to other kinds of dance you have done?

11) **Continuation**

12) Would you consider continuing dancing? Would you choose a different type of dance or any of the dances we have done?

Transport

13) Did you have to come far?

Quality of teaching

14) What did you think of the teaching?

Accessibility

15) What did you think of the rooms? How was it getting to the rooms?

Appendix E

Music in study three, four and five

Sheryl Crow – Soak up the sun

Adele – Rumour has it

Johnny Nash – I can see clearly now

Marvin Gaye – I heard it through the grapevine

Michael Jackson – Don't stop 'till you get enough

Whitney Houston – Million Dollar Bill

Leona Lewis – Forgive me

Tom Jones & Stereophonics – Mama told me not to come

The Beach Boys – Don't worry baby

Movement description

Movements adapted from PDUK Keep moving booklet and OTAGO falls prevention sessions. Exercised from 5 of the 6 constraints of PD – Horak & King (2009)- rigidity, bradykinesia, freezing, sequential coordination, impaired sensory integration. DVD created for both movement and movement to music groups.

30mins in one go

Seated

5mins warm up

- Seated marching
- Feet tap out in front of you, turning from your ankles
- Feet tap with heels, really strike floor with your heels
- Back to seated matching
- Tap and clap (lap and clap)
- Tap and clap (down to either side, up high-right and left)

Stretches

- Shoulder rolls (5 forward, 5 backward)
- Looking to left and right (moving neck) x5 each way
- Trunk rotations* (turning to look behind, hand on opposite leg and look behind) 5 secs each side
- Stretch out back, hands at the base of the back (Barbara Windsor)
- Calf stretches – heel on floor out in front, drag in a little hand on opposite leg and lean forward (each leg)

20 minutes Main activity

- Postural- correct posture – keep checking throughout. Not slumping forward.

- Heel raises x20, 2 sets (seated, stood behind the chair and holding on with hands, spider fingers, 2 fingers, 1 finger, no hands) *keeping balance. 5 x reps of going up for 3 secs, down for 5 secs.
- March it out*
- Toe raises raises x20, 2 sets (seated, stood behind the chair and holding on with hands, spider fingers, 2 fingers, 1 finger, no hands) keeping balance. 5 x reps of going up for 3 secs, down for 5 secs.
- March it out
- Practice walking movement. Deliberate heel to toe, *heel to the ground and rolling foot forward and ending with the toe, simulating walking movement – not shuffling. Shoulders back (seated, stood by chair holding on, 2 fingers, one finger, no hands)
- Sit to stand* (and back down) practice (focus on technique) x5
- When up for the last time stand next to the chair
- Single leg stands with support.* Raise one foot off the floor (can keep toe on floor for support. Up to one minute on each leg unsupported.
  Stress Ball
- Seated, squeeze ball in palm of hand. 20 x reps of each place. Out in front, down low beside the seat, out to the side, above head. Repeat with other hand. Then again 10x each
- Squeeze ball with one finger at a time, as if pinching, 10 x each finger and then 20 seconds going through each finger in turn.
  Using the ball to twist 180 each time, changing hands, then turn it the opposite way.
- Pushing ball into the chair. Push the ball intot he chair with the heel of the hand simulating pushing up out of a chair

5mins Cool Down

- 30 seconds of marching on the spot with claps.
Stretches
- Shoulder rolls (5 forward, 5 backward)

- Looking to left and right (moving neck) x5 each way
- Trunk rotations (turning to look behind, hand on opposite leg and look behind) 5 secs each side
- Stretch out back, hands at the base of the back (Barbara Windsor)
- Calf stretches – heel on floor out in front, drag in a little hand on opposite leg and lean forward (each leg)
- Side bends, as low as you can to the floor
- Arm across the body