

# Does the type of concurrent task affect preferred and cued gait in people with Parkinson's disease?

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Difficulty performing more than one task at a time is common in people with Parkinson's disease, resulting in interference with one or both tasks. While studies have shown that greater interference in gait occurs with more complex concurrent tasks, the impact of the type of concurrent task is unclear in the Parkinson's population. Thus the first purpose of this study was to investigate the effect of the concurrent task (calculation, language, or motor) on gait in people with Parkinson's disease. As visual cues are commonly used to aid stride regulation in people with Parkinson's disease, the second purpose of this study was to determine whether this method of increasing stride length was still effective if other tasks were performed simultaneously. Sixteen patients with Parkinson's disease and 16 gender- and age-matched controls performed six cognitive and motor concurrent tasks when seated, walking 10 m, and walking over visual cues. Stride length decreased in people with Parkinson's disease when performing the concurrent calculation and language tasks, but not with the motor task. The language task was more complex than the calculation task, thus the effect was not due to task complexity alone. Visual cues were effective in improving stride length whilst maintaining velocity in people with Parkinson's disease, even when performed under dual task conditions. These findings highlight the importance of the task when assessing and retraining dual tasking during gait, and suggest that retraining dual tasking can occur whilst simultaneously using visual aids to regulate stride length. [Galletly R and Brauer SG (2005): Does the type of concurrent task affect preferred and cued gait in people with Parkinson's disease? *Australian Journal of Physiotherapy* Vol 51: 175–180]

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## Introduction

Daily activities often involve performing more than one task at a time, and while most people can do several tasks concurrently, some individuals have difficulty particularly if one of the tasks requires postural control. Difficulty performing more than one task at a time (dual task interference) is more common in older than young adults (Maylor and Wing 1996, Melzer et al 2001), and in people with balance deficits (Brauer et al 2001) including Parkinson's disease (PD). Reasons for dual task interference are based on the premise that the tasks require some form of cognitive processing, and when performed together, there are insufficient resources to do both optimally (Kahneman 1973). Which task shows interference is dependent on the individual, tasks performed, and the prioritisation of the tasks.

In Parkinson's disease, there is dysfunction of the basal ganglia which results in the loss of automaticity of motor tasks such as gait. Movement then becomes slowed and conscious attention to the task and additional assistive cues are required to replace the usual automatic control (Morris et al 2000, Churchyard et al 2001). When another task is performed concurrently with the motor task, performance of either the motor or the concurrent task often drops as there are insufficient cognitive resources to perform both tasks optimally.

Dual task interference has been demonstrated in people with Parkinson's disease during standing (Marchese et al 2003, Morris et al 2000) and gait tasks (Bloem et al 2001, Bond and Morris 2000, Camcioli et al 1998, Morris et al 1996a, O'Shea et al 2002, Rochester et al 2004). One factor shown to

influence the degree of interference is task complexity. Morris et al (1996a) found that when the complexity of a sentence recitation task performed when walking increased, stride length and walking velocity reduced in people with Parkinson's disease. Similar results have been found with added motor tasks. Bond & Morris (2000) reported reductions in gait velocity and stride length when people with Parkinson's disease carried a tray with glasses, but not when the tray was carried alone; and Bloem et al (2001) demonstrated that as the complexity of a variety of concurrent tasks increased, people with Parkinson's disease demonstrated more freezing episodes and a slowing of gait.

The effect of task type on dual task interference with gait in Parkinson's disease is less clear. Decreases in stride length and velocity have been found when concurrently performing a cognitive task of sentence recitation (Morris et al 1996a) or word recitation (Camcioli 1998). Similar changes in gait have been reported when performing the concurrent motor task of carrying a tray with glasses (Bond and Morris 2000). Two studies have specifically compared the effects of concurrent cognitive and motor tasks on gait in people with Parkinson's disease and have found conflicting results (O'Shea et al 2002, Rochester et al 2004).

O'Shea et al (2002) compared gait performances when concurrently transferring coins from one pocket to another (motor task) with counting backwards by threes (cognitive task). They found that while adding either concurrent task detrimentally altered gait in people with Parkinson's disease, there was no difference in stride length, walking velocity or cadence between the motor and cognitive tasks. In contrast, Rochester et al (2004) found that people with Parkinson's disease reduced their walking speed and step length when

**Table 1.** Demographic and clinical characteristics by group.

	Parkinson's disease (n = 16)	Controls (n = 16)
Age (years)	65 (9.5)	65 (9.6)
Height (cm)	170 (8.5)	173 (11)
Sex (number of males)	9	9
TUG (s)*	9.4 (2.1)	6.9 (1.0)
TUG <sub>cognitive</sub> (s)*	11.5 (2.7)	7.8 (1.3)
TUG <sub>motor</sub> (s)*	10.3 (2.7)	7.2 (0.8)
MMSE (/30)	28 (3)	30 (1)
UPDRS II (/52)	10.9 (4.9)	-
UPDRS III (/108)	14.4 (6.1)	-
Disease duration (yrs)	9.1 (4.5)	-

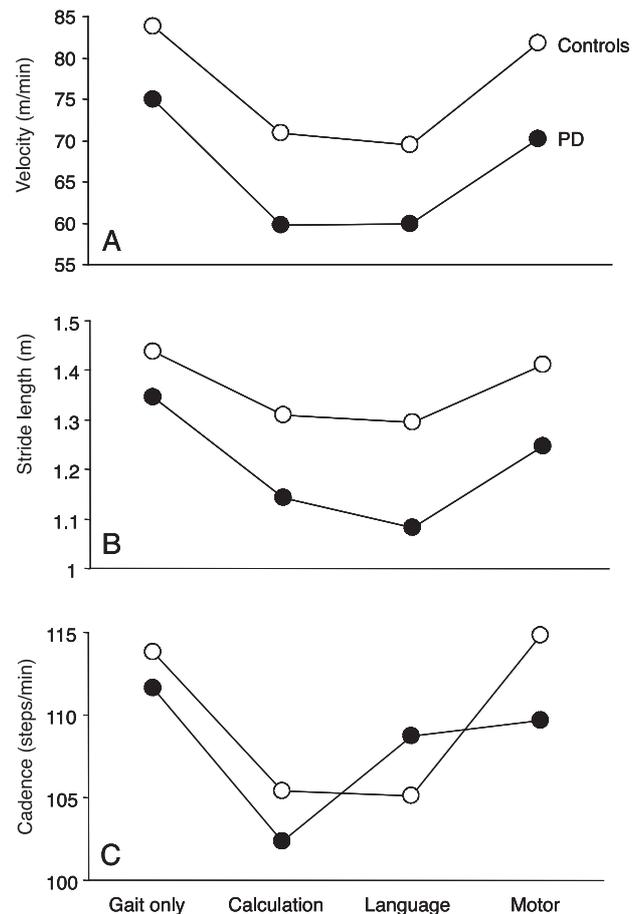
\*Between-groups  $p < 0.001$ . TUG: Timed Up and Go test. TUG<sub>cognitive</sub>: TUG whilst counting backwards by 3s. TUG<sub>motor</sub>: TUG whilst carrying a cup of water. MMSE: Mini Mental State Examination. UPDRS: Unified Parkinson's Disease Rating Scale.

concurrently answering questions, but not when carrying a tray with cups. In both studies the difficulty of the two tasks was not compared and as difficulty has been shown to have a major impact on performance, this may have influenced the results. In addition, they used cognitive tasks requiring different skills (language vs calculation) and this may be another reason for differences. Thus the first aim of this study was to compare the effect of the concurrent task (cognitive tasks requiring mathematical skills vs language skills vs upper limb motor tasks) on gait parameters in people with Parkinson's disease and controls and to use the rate of correct responses of the concurrent tasks as an indicator of complexity. We hypothesised that the more complex tasks, regardless of type, will cause greater interference with gait in all subjects.

Research has shown the benefits of using cues to assist people with Parkinson's disease to normalise their gait pattern (Morris et al 1996a), however this could essentially be considered an added task. For cued gait retraining to be progressed from the rehabilitation environment to a functional situation, attendance to both these visual cues and other added tasks such as talking or carrying an object may be required. Whether attending to visual cues and additional tasks results in dual task interference with gait is unknown. Thus, the second aim of this study was to determine whether performing added tasks whilst using visual cues to normalise gait adversely impacts performance on either task. We hypothesised that there would be a reduction in gait velocity or performance of the concurrent task when Parkinson's disease subjects use visual cues with concurrent tasks.

## Method

**Subjects** Sixteen people with idiopathic Parkinson's disease were recruited from neurological disorders clinics across Brisbane (mean age  $65 \pm 9.5$  years, range 53 to 81). They were gender and age matched (within five years) to 16 subjects unaffected by Parkinson's disease or any other neurological conditions, recruited from family of patients and The University of Queensland Australasian Centre on Ageing. Demographic and clinical details are presented in Table 1.



**Figure 1.** The effect of concurrent tasks (calculation, language and motor) on gait parameters in controls and Parkinson's disease groups. A, velocity. B, stride length. C, cadence.

Subjects were included if: they were able to walk a 12 m path 11 times with unlimited rest periods; scored  $> 24/30$  on the Mini Mental State Examination (MMSE); had no other neurological, musculoskeletal, or medical conditions that affected their gait; and were capable of giving informed consent. This study was approved by the institutional research ethics committees of both affiliations and conformed to the Declaration of Helsinki.

**Procedure** Prior to testing, each subject completed a MMSE to ensure his or her general cognitive ability met the inclusion criteria. All subjects attended one test session lasting one hour. Subjects with Parkinson's disease were tested during the self-reported 'on phase' of their medication cycles, as gait parameters are most stable at this time (Morris et al 1996b). All subjects performed the Timed Up and Go Test under single (TUG) and dual (TUG<sub>cognitive</sub> and TUG<sub>manual</sub>) conditions. These clinical tests of dual task ability during gait have proven reliability in older adults (Shumway-Cook et al 2000a). Subjects in the Parkinson's disease group were rated on sections II (activities of daily living) and III (motor examination) of the Unified Parkinson's Disease Rating Scale (UPDRS) by an experienced neurological physiotherapist (Goetz 2003).

Each subject performed one repetition of eleven different

**Table 2.** Mean (SD) gait parameters in non-cued and cued trials.

Tasks*	Velocity (m/min)		Stride length (m)		Cadence (steps/min)	
	PD	Controls	PD	Controls	PD	Controls
Non-cued						
Gait only	74.5 (12.1)	83.0 (9.2)	1.35 (0.23)	1.46 (0.12)	111.6 (15.8)	113.8 (9.90)
Calculation	59.1 (16.9)	71.7 (8.6)	1.13 (0.18)	1.36 (0.13)	103.3 (20.6)	105.7 (10.9)
Language	59.1 (16.2)	69.6 (9.4)	1.13 (0.27)	1.32 (0.14)	106.2 (16.5)	105.4 (10.7)
Motor	69.6 (15.2)	80.5 (9.4)	1.30 (0.25)	1.40 (0.12)	109.5 (24.8)	114.7 (9.80)
Cued						
Gait only	69.8 (11.7)	75.1 (7.5)	1.30 (0.09)	1.34 (0.13)	107.2 (15.4)	112.3 (12.2)
Calculation	59.9 (13.7)	67.2 (10.)	1.30 (0.09)	1.35 (0.15)	91.1 (19.2)	101.8 (13.9)
Language	58.9 (13.5)	66.8 (7.5)	1.33 (0.15)	1.31 (0.07)	89.2 (20.0)	102.2 (10.9)
Motor	70.3 (10.3)	74.4 (8.3)	1.30 (0.10)	1.32 (0.07)	108.2 (14.5)	113.9 (13.0)

\*Calculation: counting backwards by 3s. Language: words 'F' or 'S'. Motor: clicking counter.

tasks. The gait only task involved walking 10 m at a comfortable pace. The concurrent tasks involved walking 10 m whilst simultaneously performing a calculation, language, or motor task. When performing the concurrent tasks, subjects were instructed to concentrate on both the gait and the added task at the same time.

The calculation task required the subjects to count backwards in threes from a number between 20 and 100 randomly selected by the examiner (O'Shea et al 2002). For the language task subjects performed the Controlled Oral Word Association Test (COWAT). Here subjects are asked to list as many different words that begin with a specific letter, with 'F' and 'S' used for each of the two trials. The motor task required subjects to press the button on an electronic counter as many times as possible with the thumb of the preferred hand. These three tasks were also performed for one minute while sitting in a chair with armrests to get a baseline measure of task performance. The response rate (number/sec) and accuracy (100% = no errors) of task performance were multiplied to calculate the rate of correct responses as an index of task complexity.

To investigate the effect of dual tasking on visually cued gait, white strips of cardboard (300 x 50 mm) were placed along the 10 m path at the distance of the subject's age-, height- and sex- determined 'normal' step length (Morris et al 1996a) as calculated with the database supplied with the stride analyser. In the cued gait only task, subjects were asked to walk along the path stepping over the white lines. For the three cued concurrent task trials, subjects were asked to step over the white lines while concurrently performing each of the three concurrent tasks described above. The concurrent-only tasks (3), non-cued gait tasks (4), and cued gait tasks (4) were performed in separate blocks in random order, with the order of the tasks within the blocks also randomised across subjects to eliminate any learning or fatigue effects.

**Gait assessment** A 10 m walking area was marked out in a flat obstacle-free gait laboratory, with 2 m allowed at each end for acceleration and deceleration. Spatial and temporal parameters of gait were measured using the Clinical Stride Analyser<sup>a</sup>, which has been shown to be valid and reliable in the Parkinson's disease population (Morris et al, 1994). The

stride analyser uses insoles with four switches to measure parameters including stride length, velocity, and cadence. The data collection box was carried by an examiner who walked closely behind the subject and triggered the start and end of data collection manually. One practice trial was performed at the start of the session.

**Statistics** To determine the effect of task type (gait only, gait + calculation, gait + language, or gait + motor tasks), and group (Parkinson's disease or control) on gait parameters, linear mixed models were performed on the stride length, velocity and cadence data. One-way ANOVAs, independent samples t-tests (comparing groups) and paired samples t-tests (comparing tasks) were used for the *post hoc* examination of specific differences. To compare the complexity of the concurrent tasks, the rate of correct responses when seated was compared between groups using a one-way ANOVA and between tasks using paired samples t-tests. To determine the effect of cueing on gait parameters in people with Parkinson's disease, linear mixed models investigating the effect of task, group and cueing were performed. Significance was set at  $p < 0.05$ .

## Results

**Group and task type effects** A group effect ( $p = 0.02$ ) and task effect ( $p < 0.001$ ), but not a group x task interaction ( $p = 0.69$ ), were found when the velocities for the four gait tasks were investigated. As seen in Figure 1A, the Parkinson's disease group walked on average 8.5 m/min slower than the control group (74.5 m/min vs 83 m/min,  $p = 0.04$ ) in the gait only trials. When either the calculation or language task was added, gait velocity reduced in people with Parkinson's disease by a mean of 15 m/min (SD 12) ( $p < 0.001$ ), and by 5 m/min (SD 8) when a motor task was added ( $p = 0.015$ ). Control subjects showed an average reduction of 12 m/min (SD 6) with the added calculation or language task ( $p < 0.001$ ), and of 3 m/min (SD 3) when a motor task was added ( $p = 0.008$ ). Gait velocity was slower in the calculation and language tasks than in the motor tasks in both groups ( $p < 0.001$ ), but there was no difference in velocity between calculation or language tasks ( $p > 0.22$ ) (Table 2).

When the stride lengths of the four different tasks were

**Table 3.** Concurrent task correct response rate\* (means and SD).

Task	Correct response rate					
	Seated	PD Gait	Cues	Seated	Controls Gait	Cues
Calculation	0.45 (0.17)	0.59 (0.14)	0.64 (0.22)	0.49 (0.17)	0.77 (0.29)	0.78 (0.21)
Language	0.22 (0.09)	0.38 (0.16)	0.45 (0.14)	0.26 (0.07)	0.56 (0.22)	0.63 (0.20)
Motor	2.94 (0.68)	3.40 (1.02)	3.41 (1.17)	3.66 (0.73)	4.16 (0.80)	3.82 (0.88)

\*Correct response rate: response rate per second x % correct. Calculation: counting backwards by 3s. Language: words 'F' or 'S'. Motor: clicking counter.

investigated, a group effect ( $p = 0.01$ ) and task effect ( $p < 0.001$ ), but not a group x task interaction ( $p = 0.19$ ), were found. There was no group difference in stride length ( $p = 0.14$ ) when performing the gait only task, but a similar pattern to velocity was found with added tasks (Figure 1B). The stride lengths of the Parkinson's disease subjects reduced by a mean of 22 cm (SD 22) when the calculation or language tasks were added ( $p < 0.003$ ), but were not different when the motor task was added ( $p = 0.56$ ). In comparison, the stride lengths of the control subjects reduced by a mean of 12 cm (SD 9) when either cognitive task was added ( $p < 0.001$ ) and by a mean of 5 cm when a motor task was added ( $p = 0.001$ ). In people with Parkinson's disease, stride length was significantly shorter during the calculation and language tasks than during the motor tasks ( $p < 0.03$ ).

When cadence was investigated, a task effect was found ( $p = 0.005$ ), but no group effect ( $p = 0.67$ ) or group x task interaction ( $p = 0.12$ ). There was no group difference in cadence ( $p = 0.66$ ) when performing the gait only task. When the tasks were compared in the Parkinson's disease group, there was no difference in cadence between any tasks ( $p > 0.13$ ). In comparison, as seen in Figure 1C, cadence was reduced in the control subjects by a mean of 8.5 m/min (SD 6) during the calculation and language tasks ( $p < 0.001$ ), but there was no difference with the motor task ( $p = 0.45$ ). In the control subjects, cadence did not differ between the cognitive tasks ( $p = 0.73$ ), and it was lower in cognitive than in motor tasks ( $p < 0.001$ ).

**Task complexity** When performing the concurrent tasks when seated, the rate of correct responses showed a significant task effect ( $p < 0.001$ ), no group effect ( $p = 0.08$ ), and no group x task interaction ( $p = 0.25$ ). Concurrent task data are shown in Table 3. The motor task had the greatest correct response rate, followed by the calculation task, then the language task. These rates were significantly different from each other ( $p < 0.001$ ), suggesting that the language task was the most complex and the motor task the least.

When concurrent task responses were investigated while walking, the correct response rate was slower in Parkinson's disease subjects than in controls ( $p < 0.001$ ), was faster when walking than when seated ( $p < 0.001$ ), and was different between tasks ( $p < 0.001$ ). The same pattern of task complexity remained with gait and the motor task having the

greatest correct response rate and language the least ( $p < 0.008$ ).

**Visual cues** People with Parkinson's disease were able to use visual cues to normalise their stride lengths whilst concurrently performing added tasks. Stride length increased by an average of 13 cm (SD 16,  $p < 0.003$ ) for the calculation task and by 20 cm (SD 24,  $p < 0.007$ ) for the language task (see Table 2), to become no different from the stride length of the gait only or the motor task trial, which was already at normal levels. As a result, cueing reduced the cadence of the Parkinson's disease group by a mean of 12 steps/min (SD 13,  $p = 0.004$ ) for the calculation task and by 17 steps/min (SD 12,  $p < 0.001$ ) for the language task. Adding cues did not change gait velocity significantly in the Parkinson's disease group for any of the tasks (See Table 2). When cues were added, there was no change in the performance (correct response rate) of any of the concurrent tasks ( $p > 0.14$ ) in people with Parkinson's disease.

## Discussion

The results showed that the type of concurrent task was important in the degree of interference with stride length in Parkinson's disease subjects, but had less of an effect on velocity and none on cadence. People with Parkinson's disease showed a greater reduction in stride length with the added calculation or language tasks than with the added motor tasks. This shortening of stride length with added cognitive tasks is supported by previous studies of gait in Parkinson's disease patients with added cognitive tasks (Morris et al 1996a, Camcioli 1998, Bloem et al 2001, Rochester et al 2004). In addition, Marchese et al (2003) found that a counting backwards task resulted in a greater area of centre of pressure motion in people with Parkinson's disease than a finger opposition motor task. Our results are in contrast to the findings of O'Shea et al (2002). One reason for this may have been that our Parkinson's disease group showed a faster velocity and longer stride length than those studied by O'Shea et al (2002) when walking without any added tasks. If gait is more compromised in the person with Parkinson's disease, it may not matter what type of concurrent task is performed; the attentional capacity used by any added task may be enough to cause interference with gait. If the gait deficits are less, as in our population, then this may

be where the type of task may play a more important role.

Examination of concurrent task performance also supports the premise that task type and not just task complexity is important in dual task interference with gait. The language task was considered to be more complex than the calculation task in this experiment, as its correct response rate was significantly lower. Despite this, there was no difference in interference with gait between the calculation and language tasks, so aspects of the task other than complexity must have been a factor in altered gait performance. Complexity is still important, but may play more of a role when the tasks are very complex or simple, which may explain why there was little interference in stride length in people with Parkinson's disease with the motor task we studied. The results of the control subjects also support this premise. Control subjects demonstrated a reduction in stride length and velocity with all added tasks. They also had a much greater correct response rate than Parkinson's disease subjects, indicating that they may have made the concurrent tasks more complex by responding at a faster rate. The results of this study highlight the importance of clinically assessing gait with a variety of concurrent tasks, particularly cognitive ones, in the patient with Parkinson's disease.

When visual cues of paper strips were added to the tasks, there was no observable deterioration in gait velocity, stride length, or cadence in people with Parkinson's disease. That is, visual cues were effective in normalising stride length of Parkinson's disease subjects, even with concurrent tasks. Velocity did not change, remaining significantly slower than in control subjects. There was also no difference in the correct response rate of the concurrent tasks between non-cued and cued trials, indicating that they still performed the concurrent tasks at the same rate and accuracy across the different trials.

The mechanism by which visual cues are able to improve gait in patients with Parkinson's disease has not yet been determined. Two possible mechanisms have been suggested: (1) visual cues focus the attention of the person onto the gait task, in effect bypassing the automatic internal cueing device of the basal ganglia-supplementary motor area interaction that is faulty in patients with Parkinson's disease; and (2) visual cues encourage the formation of a better motor set in the supplementary motor area leading to improved motor performance from the outset (Morris et al 1996a). The fact that our study found no detriment in the ongoing performance of either task with added cues lends support to the motor set theory. Sight of the cues may help to form a more accurate motor set in the supplementary motor area which is carried through until the end of that motor sequence. If the paper strips provided regular cues to the supplementary motor area via the cortex, it would be more likely to have resulted in dual task interference with either the gait or concurrent task during testing.

These findings should be considered in light of some study limitations. First, although subject numbers were sufficient to detect differences in many of the variables, the results are based on the data of only 32 subjects. The Parkinson's disease subjects were all otherwise healthy and living independently in the community. Further research is warranted to investigate dual task interference in people with Parkinson's disease who have more severe gait deficits. Only one trial of each task was performed to ensure all tasks were attempted when medication was at its peak, similar to other studies of dual-tasking in Parkinson's disease subjects (Rochester et al 2004,

Marchese et al 2003). More trials may have reduced variance, but there were no effects nearing significance that may have altered with reduced SDs. Additional investigation of more complex concurrent motor tasks would be beneficial in determining the impact of motor task type on interference with gait. The white strips used in this study are only one form of cueing used in people with Parkinson's disease. Additional studies are required to determine whether other cues such as a written sign saying *Big Steps* are also able to be used under dual-task situations.

Part of physiotherapy treatment of gait hypokinesia in Parkinson's disease has been to encourage patients to avoid dual tasks where possible, and to teach them strategies to do so (Morris 2000). These results provide evidence that visual cues remain effective in improving stride length, even when dual tasks are performed simultaneously. Previous research has demonstrated that, with training, patients with Parkinson's disease are capable of improving motor function, and of retaining this improvement (Behrman et al 2001). If patients with Parkinson's disease are capable of attending to more than one task at a time with visual cues, it may be possible to retrain patients to do so in a variety of more functional tasks.

This study showed that the concurrent tasks requiring calculation and language skills caused deterioration in stride length in Parkinson's disease subjects, while the concurrent button-clicking motor task did not. The language task was more complex than the calculation task, thus the effect was not due to task complexity alone. Visual cues remained effective in improving stride length of people with Parkinson's disease while concurrent tasks are being performed, suggesting that the attention capacity or ability to prioritise activities is not exceeded in this situation. Finally, further study is required to observe whether patients are able to practise and learn to attend safely to more than one task at time.

**Footnotes** <sup>a</sup>B&L Engineering, California, USA.

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