

# Prevalence and pattern of perceived intelligibility changes in Parkinson's disease

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*J Neurol Neurosurg Psychiatry* 2007;**78**:1188–1190. doi: 10.1136/jnnp.2006.110171

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Received 6 November 2006  
Revised 13 March 2007  
Accepted 15 March 2007  
Published Online First  
30 March 2007

**Background:** Changes to spoken communication are inevitable in Parkinson's disease (PD). It remains unclear what consequences changes have for intelligibility of speech.

**Aims:** To establish the prevalence of impaired speech intelligibility in people with PD and the relationship of intelligibility decline to indicators of disease progression.

**Methods:** 125 speakers with PD and age matched unaffected controls completed a diagnostic intelligibility test and described how to carry out a common daily activity in an "off drug" state. Listeners unfamiliar with dysarthric speech evaluated responses.

**Results:** 69.6% (n=87) of people with PD fell below the control mean of unaffected speakers (n=40), 51.2% (n=64) by more than -1 SD below. 48% (n=60) were perceived as worse than the lowest unaffected speaker for how disordered speech sounded. 38% (n=47) placed speech changes among their top four concerns regarding their PD. Intelligibility level did not correlate significantly with age or disease duration and only weakly with stage and severity of PD. There were no significant differences between participants with tremor dominant versus postural instability/gait disorder motor phenotypes of PD.

**Conclusions:** Speech intelligibility is significantly reduced in PD; it can be among the main concerns of people with PD, but it is not dependent on disease severity, duration or motor phenotype. Patients' own perceptions of the extent of change do not necessarily reflect objective measures.

Voice and speech changes are inevitable in Parkinson's disease (PD) as the condition progresses.<sup>1,2</sup> The consequences of these changes for intelligibility and acceptability of spoken communication are unclear.

Previous surveys<sup>3-6</sup> estimate 70–90% of patients with PD present with voice changes, 45–55% with speech changes. Only Coates and Bakheit<sup>6</sup> focused directly on intelligibility, determining 65% of 48 participants had problems. This study had several drawbacks, including lack of control recordings, grading of intelligibility by a single speech language therapist and failure to match word lists presented to different speakers.

We assessed a large sample of people with PD using a diagnostic intelligibility test<sup>7,8</sup> with evaluation of responses by listeners with no professional or personal experience of listening to disordered speech or association with PD. We compared results of PD subjects to an age matched control group and in relation to a variety of indicators of disease progression.

## METHODS

### Participants

We recruited subjects from a community and hospital acquired cohort of patients<sup>9,10</sup> meeting UK Parkinson's Disease Society Brain Bank Criteria for PD.<sup>11</sup> Individuals were excluded if they had a history of speech-language disorder prior to PD symptoms onset, comorbidity associated with speech changes, did not speak English or did not wish to join the study.

Friends and family members of individuals with PD involved in the study participated as control speakers. Volunteers with a history of neurological disorder, speech-language problems or English as a second language were excluded.

The study was approved by the Sunderland Research Ethics Committee.

### Assessment

Participants were assessed first thing in the morning, at home, with antiparkinsonian therapy withheld and fasting since midnight. A practically defined "off state" Unified

Parkinson's Disease Rating Scale (UPDRS),<sup>12</sup> Hoehn and Yahr rating,<sup>13</sup> cognitive testing<sup>14</sup> and depression rating<sup>15</sup> were performed approximately 2 weeks prior to speech testing. Motor phenotype (tremor dominant, posture and gait instability or indeterminate) was derived from the UPDRS score.<sup>16</sup>

### Materials and procedure

The intelligibility measure was a 60 item test based on Yorkston *et al.*<sup>8</sup> Six matched minimally differing word lists were created. Participants read one of these systematically rotated lists with words appearing singly on a computer screen, the rate dictated by the speaker. Six further parallel lists of foils were devised. Responses were digitally recorded, utilising a constant recording level (Marantz Professional PMD690) with an AKG (C420) head mounted microphone. Control speaker intelligibility testing took place under identical circumstances.

### Intelligibility rating

Listeners (blind to any speaker or word list variables) scored the de-noised and cleaned recordings, circling from 12 options (see samples in the appendix) the word they thought they heard. On sentence items, listeners checked only the varying word. Items were played one at a time and heard only once. Control speaker scores provided norm references for judgements on severity of intelligibility impairment.

### Listeners

Following standard practice,<sup>7,8</sup> to minimise listener variability effects<sup>17,18</sup> and overestimation of scores through familiarity with word lists,<sup>19</sup> three listeners scored each speaker independently; each listener heard only five tracks; and grouping of listeners was systematically varied to avoid the same trio evaluating successive tracks. Raters had no prior experience of PD or listening to disordered speech. The final score was the mean total words

**Abbreviations:** MMSE, Mini-Mental State Examination; PD, Parkinson's disease; UPDRS, Unified Parkinson's Disease Rating Scale

correctly identified across the three listeners. The 99 listeners (mean age 40.5 (SD 20.96) years, range 18–83) required for the 125 patient and 40 control recordings using this procedure received a £5 (approximately Euros 7.50; US\$ 9.50) store voucher.

### Perceived disorderedness of speech

People with PD and control speakers described how to make a cup of tea. Listeners rated whether “this person has a problem with spoken communication” on a 5 point scale (1 strongly agree; 5 strongly disagree). The 5–10 s recording excerpts contained no inappropriate pauses, restarts or word retrieval gaps.

At assessment, PD subjects rated whether “My voice is not as good as it used to be”; “When I speak sounds come out slurred and unclear”; “I am happy with my speech as it is now” on 5 point scales from strongly agree to strongly disagree. They ranked where speech changes came in relation to other concerns associated with their PD.

Statistical analysis was carried out via SPSS for Windows 14.0. Non-parametric methods (Mann–Whitney for two independent groups, Kruskal–Wallis test for more than two independent groups,  $\chi^2$  test and Spearman's rho) were used to investigate the non-normally distributed data.

## RESULTS

We recruited 176 subjects with PD potentially agreeing to join a study. They were younger than those not agreeing (mean age 70.2 years vs 77.0 years, Mann–Whitney  $p < 0.001$ ) and less likely to be living in residential or nursing care ( $\chi^2$ ,  $p < 0.001$ ).<sup>9–10</sup> A total of 140 agreed to participate in this study. Complete intelligibility tests were obtained from 125 individuals (table 1). Fifteen were incomplete because of visual acuity or reading difficulties or because of technical problems with sound recordings. Mann–Whitney comparisons indicated no significant differences in age, disease duration, Hoehn and Yahr stage or UPDRS II and III totals between the 125 participants and 51 individuals without an intelligibility score.

Forty family members and friends of participants with PD (mean age 70.2 (SD 8) years; 21 female) were recruited as control speakers for the intelligibility test. Fifty-seven further subjects (mean age 57.9 years; median 64; range 23–87) were recorded describing “how to make a cup of tea” to provide control data for listener perceptions of disorderedness of speech.

### Intelligibility

Listeners recognised a mean of 49.6 words from the PD group (SD 7.0) compared with 54.6 words (SD 3.6) from controls (Mann–Whitney,  $p < 0.001$ ); 69.6% ( $n = 87$ ) of people with PD fell below the control mean (51.2% ( $n = 64$ )  $> -1$  SD below).

Significant, albeit only moderate, Spearman's correlations existed between intelligibility scores and Hoehn and Yahr stage ( $r = -0.263$ ,  $p = 0.003$ ); UPDRS II ( $r = -0.4$ ,  $p < 0.001$ ) and UPDRS III ( $r = -0.40$ ,  $p < 0.001$ ); and cognition<sup>14</sup> score ( $r = 0.317$ ,  $p < 0.001$ ). Age showed a borderline significant association with intelligibility ( $r = -0.167$ ,  $p = 0.06$ ), while time since diagnosis ( $r = -0.020$ ,  $p = 0.81$ ), duration of treat-

ment ( $r = -0.058$ ,  $p = 0.542$ ) and depression rating ( $r = -0.157$ ,  $p = 0.82$ ) did not.

A linear regression model was constructed to examine the effect of age, gender, disease duration, stage,<sup>12–13</sup> cognitive status (Mini-Mental State Examination (MMSE)<sup>14</sup>) and depression<sup>15</sup> on intelligibility. Best fit was obtained with UPDRS III and MMSE ( $R^2 = 0.217$ , adjusted  $R^2 = 0.204$ ). There was no significant difference between motor phenotypes by intelligibility scores (Kruskal–Wallis test,  $p = 0.36$ ). Tremor dominant ( $n = 38$ ) and postural instability ( $n = 62$ ) subtypes also did not differ significantly (Mann–Whitney,  $p = 0.18$ ).

### Disorderedness ratings

The median rating for PD subjects was 3 (IQR 2–3) compared with a median rating of 4 (IQR 3–5) for control speakers (Mann–Whitney,  $p < 0.001$ ). Forty-eight per cent ( $n = 60$ ) of people with PD were rated as worse than the poorest control speaker.

### Self-perception ratings

Seventy-six per cent of the PD group felt their voice was not as good as it used to be; 56.5% reported their speech was slurred. Only 4.2% reported no speech–language changes, although 18.1% were happy with how they spoke. Ten per cent of PD subjects rated speech–voice changes as their number one concern regarding changes associated with PD; 38% placed speech among their top four concerns.

## DISCUSSION

This study demonstrates that listeners find more than 50% of PD subjects difficult to understand and 38% of patients with PD rate speech difficulties as a major concern. Speech intelligibility is not, however, strongly associated with PD motor phenotype or measures of disease severity. Several possibilities may account for the latter.

The proportion of participants in Hoehn and Yahr stages 1–1.5 and 4–5 was relatively low compared with other stages, although representative of patterns in other studies.<sup>20</sup> Acquisition bias towards mild–moderate disease severity may have masked a possible association, while fluctuation in motor state related to the time between motor and speech assessments could have contributed. Measures of limb and axial motor involvement may not necessarily reflect changes in speech motor control.<sup>21–22</sup> Intelligibility represents what the speech control processes can achieve employing all possible compensatory tactics. It also reflects listener effort. The latter effects might account for the apparent lack of deterioration in intelligibility in the early phases of PD.

Intelligibility tests may overestimate the size of the problem as other variables contribute to message transmission in the face of imprecise speech or quiet voice.<sup>23</sup> Conversely, scores may underestimate the problem. People with PD can raise their speech performance when concentrating in short bursts when it matters,<sup>24</sup> situations which may theoretically include research assessments. Reading single words for an intelligibility test is cognitively relatively undemanding. When people with PD

**Table 1** Age and disease specific details for the 125 participants with Parkinson's disease

	Mean	median	SD	Range (IQR)
Age (y)	71.5	73	8.6	45–91
Time since diagnosis (y)	8.12	5	6.9	1–38 (IQR 3–11)
Hoehn & Yahr stage (max 5 severe)	2.5	2.5	0.88	1–5 (IQR 2–3)
UPDRS II (max 52 severe)	14.6	15	6.4	1–33
UPDRS III (max 108 severe)	34.5	34	14.9	8–73
MMSE <sup>14</sup> ( $\geq 23$ normal)	25.3	27	3.7	14–30 (IQR 23–28)
GDS <sup>15</sup> ( $\leq 4$ normal)	4.8	4	3.3	0–14 (IQR 2–7)

GDS, Geriatric Depression Scale; MMSE, Mini-Mental State Examination; UPDRS, Unified Parkinson's Disease Rating Scale.

speak in conditions simulating day-to-day conversation, speech scores can fall significantly.<sup>25</sup> The “self-perception” ratings reported in this study may be supportive of this theory.

We have shown that intelligibility of speech to everyday listeners is reduced in people with PD compared with matched control speakers, with communication difficulties not dependant on disease severity, motor phenotype or disease duration. We have also demonstrated that people with PD rate their own communication difficulties as a key and important problem. Further research is required to investigate the interactions of intelligibility scores with cognitive and mood status and self-perceptions of change.

## ACKNOWLEDGEMENTS

Sarah-Jane McLea, Sheila Robson, Claire Turner and Sarah Wood assisted with listening sessions for scoring the intelligibility tests and disorderedness ratings. Maria Wolters kindly de-noised the audio files.

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Funding: The research was supported by a grant from the Parkinson's Disease Society (UK). LA was supported by an NHS Research and Development Training Fellowship RRCC/01F/019. Funders played no part in the collection, analysis or interpretation of the data, or in writing the report or the decision to submit for publication.

Competing interests: None.

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## APPENDIX 1

Table A1 lists the sample items from the intelligibility test score sheet

cub	coop	cup	carp	keep	sheep
cape	heap	cop	hub	cap	hoop
one	fall	what	wash	waltz	wool
watts	was	wad	want	warn	watch
It was a lace meeting	It was a late meeting	It was a grace meeting			
It was a race meeting	It was a rate meeting	It was a great meeting			
It was a gate meeting	It was a guide meeting	It was a Greece meeting			
It was a grade meeting	It was a grey meeting	It was a gay meeting			
Dodder	Dosser	Dotter	Topper	Hopper	Robber
Dollar	Docker	Doffer	Stopper	Dobber	Rocker
That girl's body	That girl's fatty	That girl's forty	That girl's ratty		
That girl's potty	That girl's Patty	That girl's petty	That girl's dotty		
That girl's Betty	That girl's batty	That girl's party	That girl's daddy		
Can you cut down the plane please	Can you cut down the steaks please				
Can you cut down the place please	Can you cut down the plates please				
Can you cut down the seats please	Can you cut down the peas please				
Can you cut down the piece please	Can you cut down the pain please				
Can you cut down the space please	Can you cut down the pace please				
Can you cut down the lace please	Can you cut down the lane please				