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Communication changes in Parkinson's disease

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Abstract

Parkinson's disease (PD) is a degenerative neurological disorder. Depletion of dopaminergic nigrostriatal neurons gives rise to alterations in movement. Voice and speech, as dependent on movement of the articulators, are not spared. Non-dopaminergic changes can also affect language, cognition and mood, which can impact on communication.

This article offers an overview of changes to speech and voice that arise in PD and the impact these underlying changes have on speech naturalness, intelligibility and participation in social life. Assessment and treatment are not a focus, but lessons for these areas are drawn from the description of the nature of overall changes.

PD is also predominantly a disease of old age. Many of the alterations to speech and communication characteristic of PD also occur as part of the natural ageing process. Hence the article stresses that understanding communication alterations and their evaluation and treatment must happen within the context of age related changes.

Introduction

Parkinson's disease (PD) is essentially a disease of older age. The prevalence of PD in industrialised countries is approximately 0.3% of the entire population, rising to around 1% in people over the age of 60 and 3% over 80 years. This gives a prevalence of between 100–200 people with PD per 100,000 of the population, and incidence around 11-20/100,000 population (Macphee & Stewart, 2007, Taba & Asser, 2004, Campenhausen, Bornschein, Wick, et al. 2005). The wide variation in estimates stems from some natural geographical variation, but also from the varied methods used to ascertain data. Of those diagnosed with PD annually only around 1 in 20 are under the age of 40.

As regards communication, large scale surveys suggest around 85-90% of people with PD experience voice changes and up to half have additional decline in articulation (Hartelius & Svensson, 1994; Ho, Iansek, Marigliani, et al. 1998; Sapir, Pawlas, Ramig, et al. 2001). Voice and speech deterioration may play a significant role in terms of impact of communication changes on individuals' lives, even before underlying decline is severe (Miller, Noble, Jones & Burn, 2006a, 2006b). It is also recognised that PD may lead to alterations in cognitive performance that have implications for language processing (Grossman, Lee, Zurif, et al. 2002, Bruna, Subirana, Villalta, et al. 2008).

PD is a progressive neurological illness linked to degeneration of dopaminergic cells in the substantia nigra of the basal ganglia. However, noticeable symptoms tend not to appear until depletion is considerably advanced. This does not mean though that individuals diagnosed with PD do not sense something is awry with them in the long prodromal period. Indeed, using sensitive acoustic and kinematic analyses one is able to detect changes to voice and speech well before overt symptoms become established (Harel, Cannizzaro, Cohen, et al. 2004, Stewart, Winfield, Hunt, et al. 1995). Given the long prodromal phase it is also likely that many older people live and die with undiagnosed. The differential diagnostic challenges

of PD also mean that around 10-20% of cases may go un- or misdiagnosed (Schrag, Ben-Shlomo & Quinn, 2002).

The cardinal symptoms of PD are bradykinesia (slowness) and rigidity of movement, with tremor at rest. These are interpreted as leading back to the loss of dopamine and its effects on motor control networks. However, loss of dopaminergic cells and/or other changes in the PD brain affect not just motor control. Autonomic and cognitive systems are also impaired (Martinez-Martin, Schapira, Stocchi, et al. 2007; Macphee & Stewart, 2007; Bruna et al., 2008; Jankovic, 2008). These in turn have implications for communication – including consequences for cognition, attention, mood/depression in general, and gesture and language in particular.

When Dr James Parkinson made his original case descriptions of 'The shaking palsy' in 1817 (Parkinson, 1817) he already noted "...It was with difficulty he uttered a few words. What words he could still utter were monosyllabic and these came out after much struggle in a violent expiration and with such low voice and indistinct articulation, as to hardly be understood by those that were constantly with him. He fetched breath rather hard...." This encapsulates the essential points regarding what speech sounds like - a quiet voice, indistinct articulation, rushes of speech. More recent descriptions have emphasized too loss of loudness and reduced pitch variation.

This article will follow the ICF framework for description of conditions (Threats, 2008) and examine communication in PD firstly from the point of view of underlying impairment, then what effects these changes have on daily activities and finally on consequences of activity limitation for participation restriction and impact on the speaker and their family. Brief sections will deal with the assessment and treatment of communication changes in PD, but these are not the prime focus of this work.

Impairment level changes to voice and speech in PD

Breathing provides the driving force for speech production. Perturbation of the air-stream as it passes through the constricted larynx provides the sound source for speech. The resultant vocal note is modified by approximations and closures of the velopharyngeal and oral-labial articulators to produce what we hear as speech sounds. Variation in the balance between respiratory driving pressure and tightness of the laryngeal closure delivers contrasts in loudness, pitch and voice quality. All these elements work as a finely balanced, integrated system. All of the subcomponents – breathing, laryngeal function, articulator movement – as well as their integration for smooth, fluent speech - can be affected in PD.

Studies indicate that in comparison to speakers without PD, those with PD generate similar subglottal pressures in speech breathing and duration of inspirations between speech breath groups (Solomon & Hixon, 1993). However, on starting to speak people with PD tend to commence with smaller rib cage and larger abdominal volumes; a proportion of speakers with PD begin speaking with a lower lung volume and continue speaking after they have exhausted their tidal end expiratory level (Bunton, 2005). These same people tend to terminate breath groups at inappropriate word or grammatical boundaries. They have difficulty adjusting air volume to anticipated phrase length – i.e. no deeper breath for longer upcoming phrase. This points to a relatively intact mechanics (equivalent values to unimpaired speakers can be achieved if needs be), but deficient instantiation.

Investigations suggest these deficiencies are not a simple result of age related alterations to elasticity of the respiratory apparatus or increased likelihood of airways comorbidity in the elderly, nor of rigidity of the rib cage due to Parkinsonian changes to stiffness (Skodda & Schlegel, 2008). Rather, speech breathing changes are more likely associated with the underlying problem in scaling movements and difficulties in switching between movements

and consequent dis-coordination that people with PD experience. These bring about inefficient air utilization.

Breath use can also be affected by escape of air within the overall speech production system. (Solomon & Hixon, 1993) found a comparable tracheal pressure but lower oral pressure for their speakers with PD. Inefficient breath patterns may thus also arise from poor velopharyngeal and oral valving due to incomplete articulatory closures. Therapeutically then one might envisage treating breathing for speech either by improving articulatory performance or targeting air volume and expiratory control. Current pointers are that the latter is more efficient for people with PD (de Angelis, Mourao, Ferraz, et al. 1997; Sapir, Ramig & Fox, 2008; Sapir, Ramig, Fox & Spielman, 2007).

Laryngeal dysfunction in PD is well documented and frequently the first feature of perceived impending decline (Oguz, Tunc, Safak, et al. 2006; Stewart, Allen, Tureen, et al. 1997; Holmes, Oates, Phyland & Hughes, 2000; Midi, Dogan, Koseoglu, et al. 2008). Amplitude and pattern of closure and vibrations is altered and there are shortcomings in glottal resistance. There may be vocal cord bowing. In some speakers tremor elements affect function. The sum effect is to produce voice with a lower sound pressure level (perceived as quiet or weak voice with little variation in intensity or loudness), reduced variation in frequency (heard as tendency to monopitch, flattened intonation). A common finding concerns differences between men and women (men tend to have raised fundamental frequency) which may relate to contrasts in laryngeal and more general vocal tract geography. Perceptually the voice may be perceived as more breathy. Difficulties switching between articulatory settings leads on occasions to speech that is continually voiced or continually voiceless.

Again one has to be careful in inferring that all these changes are due to PD. In studies where age matched comparators have been included not all voice parameters have differed

significantly between groups. Furthermore, voice changes must be interpreted in the context of altered respiratory control, given that normal loudness and pitch variations are outcomes of interaction between laryngeal and breathing variables. A significant factor too must be the repeated finding that people with PD sense they are shouting when in fact their voice is abnormally quiet (Ho, Bradshaw & Jansek, 2000; Miller et al., 2006b), though not every study has demonstrated this (Dromey & Adams, 2000). This again suggests an internal scaling and perceptual factor playing a role in voice control in PD.

Velopharyngeal function has not been described in as much detail as other articulatory dimensions (Hoodin & Gilbert, 1989). Increased nasal airflow is demonstrable in speakers with PD, but debate continues concerning whether hypernasality is a significant factor in reduced communicative effectiveness.

Movements of the tongue and lips have been extensively examined (Ackermann, Konczak & Hertrich, 1997; Goberman, 2005; Rosen, Kent, Delaney & Duffy, 2006; Gabbert-Downs, Garst, Dewey & Katz, 2007). By and large, indications are that people with PD can reach similar articulatory velocities to unimpaired speakers, though some researchers have found reduced peak velocities. Movement durations on opening gestures are similar to in healthy speakers. The same is not true for closing gestures which show shorter durations. The correlates of this are the characteristic undershooting of articulatory movements found in PD. These lead to an indistinct articulation; tendency to centralisation of vowels; and so-called spirantisation of consonants - a /b/ sound is heard as /β/, /t/ as /s/ and so forth. Precision in stressed syllables may be maintained at the expense of sound realisations in unstressed syllables, which are particularly prone to articulatory breakdown (Ackermann & Ziegler, 1991; Kegl, Cohen & Poizner, 1999) have shown that the same effects are observed in the manual gestures of people with PD who use deaf sign language.

As already noted, there is a prominent prosodic disturbance in PD related to the changes to sound pressure level and its variation and alterations to control of fundamental frequency level, range and variation. These change speech in the direction of perceived monoloudness and monopitch. There is a loss of contrasts in loudness between stressed and unstressed syllables and words, and distinctions in meaning based on contrasts in intonation become problematic (Penner, Miller, Hertrich et al. 2001; Pell, Cheang & Leonard, 2006; Goberman, Coelho & Robb, 2005).

The question of whether rate of speech is affected in PD has drawn conflicting conclusions. Perceptually listeners may certainly sense increased speed of speaking. This has been demonstrated by (Torp & Hammen, 2000) who matched people with and without PD on their rate of speech and played recordings of them to listeners. They consistently perceived the people with PD to be speaking quicker, even though they were no faster than the matched controls.

This effect may be an auditory illusion stemming from the shared characteristics of fast speech and features of PD speech. In both there is a flattening of intonation, move to monoloudness and rise in fundamental frequency. There is a tendency to elide words and phrases, with loss of pauses between words and loss or deemphasizing of unstressed syllables. Articulatory contacts tend towards undershooting.

When objective measures are used to compare rate of speech in individuals with and without PD the general finding is that people with PD produce essentially the same rate as healthy controls. Only around 10% (Logemann, Fisher, Boshes & Blonsky, 1978; Ludlow & Bassich, 1984) appear to have accelerated speech. Firm generalisations are difficult given the variety of group sizes and composition, whether control speakers have been used, speech elicitation tasks chosen and measurement parameters and techniques employed. A case in point concerns the fact that if one compares rate of speech in the first versus last sentence

of a reading passage or similar with speakers with PD, then one observes a quickening in the later sections. (Skodda & Schlegel, 2008) found this, but they also noted the same tendency in their matched controls (albeit to a lesser degree). They also established that their participants with PD spoke slower with age, reflecting the tendency in the healthy population.

What does differ is that people with PD tend to have shorter or absent pause times at grammatical junctures or even between words and syllables in phrases (Rosen et al., 2006; (Skodda & Schlegel, 2008). This may lead to overall shorter speaking time, even though velocity of the articulators during speech remains comparable across groups. Another feature of Parkinsonian speech is that there may be short rushes, akin to the festination seen in gait (Moreau, Ozsancak, Blatt, et al. 2007). These may be uttered at faster than habitual rates and contribute to the impression that speech rate in PD is accelerated. However, they are not typical of all utterances in PD.

According to all these studies movements of the articulators, from diaphragm to lips, are clearly affected in PD. Speech shares with limb impairment slowed movement, reduced and reducing movement amplitude on repetitive movements, difficulties with initiation of movement. The underlying motor breakdown in PD is not however reduced range and speed of movement per se, as in some other neurological disorders. People with PD are capable of movements of normal force, velocity and amplitude. Research points rather in the direction of dysfunction in scaling movements and sustaining the dynamics of movements (Solomon & Robin, 2005; Ho, Bradshaw, Iansek & Alfredson, 1999).

It is also becoming increasingly clear that speech may be controlled differently to limb movements. In particular it appears that speech (and swallowing) may depend more on axial motor control networks, non-dopaminergic pathways (Ackermann & Ziegler, 1991; Hunter, Crameri, Austin, et al. 1997; Goberman, 2005). This in turn may explain some of the

divergences between limb and speech motor control findings and differential responses to medical and surgical interventions in PD (see below).

Effects of voice and speech changes on activities of daily living

It is well recognised that changes in one level of ICF descriptive categories does not necessarily predict nature and severity of alterations in others (Clark, 2003; Midi, Dogan, Koseoglu, et al. 2008; Hartelius, Elmberg, Holm, et al., 2008). For this reason one must consider changes in each level independently. As stated previously, changes to underlying processes in speech and voice production can be detected instrumentally even in the prodromal period and soon after diagnosis. These changes can already have consequences for psychosocial aspects of communication (see below). Typically, however, it is a while after diagnosis before deterioration produces a direct effect on daily living activities.

(Miller, Allcock, Jones, et al. 2007) compared the performance of a community and hospital based cohort of people with PD on a diagnostic intelligibility test with age matched control speakers. They found that 70% of the people with PD fell below the mean for control speakers in intelligibility, with 51% $>-1SD$ below the control mean. Intelligibility changes did not alter in relation to age or disease duration and related only weakly to measures of overall motor decline (Hoehn and Yahr stage, Unified Parkinson's Disease Rating Scale. PD subgroups PIGD (postural instability gait disturbance) and TD (tremor dominant) (Jankovic, McDermott, Carter, et al. 1990) did not differ significantly from each other. This most likely reflects the fact that intelligibility is the outcome of multiple adjustments - both by speakers when producing speech and listeners in perceiving it. Possible differences between subgroups that may exist on impairment measures therefore become blurred due to these compensatory adjustments.

Results suggest that speech does not decline in parallel to other motor aspects in PD. As regards intelligibility this is partly because, as just stated, one is able to compensate to an extent for perturbations to speech output, and listeners too can adjust to indistinct speech – especially, like family members, if they hear it every day. Clearly there comes a stage when the speaker can no longer make up for underlying decline and real intelligibility deterioration takes place, but as the findings of Miller et al suggest, this is not until some time after diagnosis. If speech deteriorates at a more rapid rate, then it is suggestive of an atypical Parkinson's picture – progressive supranuclear palsy or multiple system atrophy (Muller, Wenning, Verny, et al. 2001; Jankovic, 2008).

Another reason why speech (and swallowing, which some logopaedists consider to be within their remit) does not decline in parallel to other motor functions is that it is controlled through separate, more axial circuits, than limb movement (see section above on motor control).

Activities of daily living are influenced not just by level of intelligibility. Listeners and speakers can react negatively to what to them is an unnatural voice or speech (Southwood, 1996). Measurement of voice and articulation naturalness is therefore an important dimension in assessment of communication in PD.

The prosodic disturbance in PD can lead to the misinterpretation of affect. The monopitch and reduced and flattened loudness profile may mislead listeners to suspect depression or indifference, even when this is not present (Flint, Black, Campbell-Taylor, et al. 1992; Pell et al., 2006).

Communication takes place not just through speech. Facial expression and accompanying arm gestures also support meaning and interaction. The misinterpretation of affect may be magnified by the lack of variation in facial expression (hypomimia) and poverty of arm movements that typically accompany PD (Pell et al., 2006; Garcia & Dagenais, 1998; Tickle-

Degnen & Lyons, 2004). Mismatch between spoken and gestural and facial expression messages may mislead listeners, with the combined auditory-visual message being more difficult to correctly interpret than the spoken or visual message alone.

Facial and limb gestures are employed to gain entry to a conversation and hold one's position in the interaction. If these are affected, this can be detrimental to these aspects of day to day interaction (McNamara & Durso, 2003). Speakers face problems signalling that they wish to contribute to a conversation and once in the conversation listeners misinterpret hesitations and silences and absence of gestural indications that the speaker must have finished their contribution, and so 'steal' their turn from them. Again, this gives indications for dimensions to assess to gain a full picture of communicative competence in PD. It also points to areas of attention for therapy, in education of communication partners and in training speakers how to gain and maintain turns in conversation.

Furthermore, while speech may remain intelligible, this can be at the cost of considerable effort on the part of the listener in terms of attentiveness of listening. For the speaker it can cost considerable physical effort to uphold optimum performance. Thus whilst assessments may not show a fall in intelligibility in the ideal clinical situation, ease of listening ratings may decline, especially in day to day communication contexts. Fatigue and attentional decline may influence performance of the speaker (Solomon, 2006; Bunton & Keintz, 2008). Hence it is important in assessment to evaluate communication not just in a quiet clinic, but to gauge intelligibility with objective tests (Kent, Weismer, Kent & Rosenbek, 1989; Arcusa & Alvarez, 2004) and measure the effects on intelligibility of environment, listener skills and the secondary effects of fatigue and attention.

Effects of voice and speech changes on participation

Participation restriction concerns the effects of dysfunction (here the underlying speech motor control parameters and resultant alterations to intelligibility and acceptability of speech) on the ability and willingness of a person to participate in all the roles and situations they previously were able to or wish to.

This can involve roles within the family, where people with PD may lose their role as decision maker or figure of authority (usually unjustifiably – since unclear speech does not equal unclear thinking), or they may no longer (feel they are) be able to participate in such roles as playing and reading with grandchildren, communicating over the telephone. It may entail loss of leisure pursuits and social interaction (Miller, Noble, Jones, et al. 2008; Yorkston, Baylor, Dietz, et al., 2008; Walshe, Peach & Miller, in press), especially where these take place against background noise or where speed and fluency of speech is paramount. Early termination of employment brings not just social and psychological costs, it can result too in financial hardship.

Communication changes and loss of roles and relationships can exercise an effect on self-esteem and one's view of oneself. Someone who previously found talking a pleasure may now find it frustrating and unsatisfying; someone previously talkative may become withdrawn or feel inadequate; someone confident in communication may now feel shy or uncertain; it may no longer be so easy to get one's message across; people may mistake an individual as incompetent or unintelligent. In conversations and questionnaires with people with PD and their families, these are precisely what investigators find (Miller et al., 2008; Yorkston, et al. 2007a).

An important factor here is that degree of psychosocial impact need not relate at all to the level of underlying impairment. Someone with an apparently mild speech disorder may experience maximal impact on their self-esteem and participation in life, whilst someone with what sounds like a serious dysfunction may be able to carry on life as normal. Occasionally

one finds individuals for whom diagnosis of a progressive disorder may even be by a positive event. One person in the study by (Miller et al., 2008) felt that coming to terms with having PD had given her 'the incentive to be positive in everything I say and do', to see what she was still capable of despite her PD.

This underlines that evaluation of communication disturbance in PD, as with other neurological conditions, must take place on an individual basis within the context of the person's own life. Relationship to norms of scores on impairment measures will tell one little about success as a communicator. At the same time it reemphasizes that management needs to be sited in the individual's whole context. Isolated focus in treatment on lip movement or respiration without attention to communication as a whole is likely to remain unsuccessful.

Assessment

The aim of this article has been to outline changes to communication in PD, not to detail speech language therapy clinical management. Nevertheless, the description above offers some clear guidelines for assessment and treatment.

Evaluation of impairment level parameters provides a method to detect early changes in speech articulator motor function and to track underlying impairment over time. However, these variables will not capture changes in intelligibility and naturalness of speech. For this diagnostic intelligibility testing (Arcusa & Alvarez, 2004) and use of perceptual rating scales are necessary (Karnell, Melton, Childes, et al., 2007). In turn, these assessments do not target how successful an individual might be as a communicator. To evaluate this dimension measures of communicative efficiency and success (Walshe et al., in press; Yorkston et al., 2007a) are required. As communication is a social phenomenon, always involving at least

two people, then ideally this assessment is conducted in naturalistic settings with key communication partners.

Communication is also affected by how much of an impact the changes might have on an individual and their family, independent of the impact that changes to mobility and so forth might also bring. For that reason it is invaluable to gauge psychosocial impact and changes in this over time.

Limb control has not been a focus of this article. However, changes to limb control have a direct affect on writing and keyboard use which can add to the communication disability in PD. The micrographia characteristic of PD (Jankovic, 2008; Kim, Lee, Park, et al. 2005) may even be an earlier sign of disease onset than speech decline.

Other non-speech functions interact with communication. For a comprehensive assessment therefore it may be relevant to assess cognition (including language), attention, mood and fatigue. As performance may differ appreciably across the course of the drug cycle or at different times of the day, then follow-up assessments must be conducted at equivalent times, or possible variation must be taken into account when interpreting outcomes.

Findings need to be interpreted in the context of other age related changes, as opposed to just PD related decline. There is a tendency for fundamental frequency to alter and voice to become quieter with age. Speech becomes slower, breathing volume declines (Rosen et al., 2006) (Verdonck-de Leeuw & Mahieu, 2004). Language function may alter (Lopez-Higes-Sanchez, Rubio-Valdehita, Martin-Aragoneses & Del-Rio-Grande, 2008). Furthermore, there may be happenings socially that bear on communication. Loss of or change in employment and retirement alter social roles and expectations. Loss of contact with previous social networks changes the amount one might communicate. Even without PD, reduced mobility may impact on communication. Hearing loss and visual changes can affect communication.

The health and communication status of a partner may also influence the situation. Hence, as ever, speech and voice must be evaluated in real life situations as well as on more formal clinical tests.

Treatment

The success of medical and surgical interventions is mixed. The case for these bringing about changes in underlying motor performance and associated speech tasks is strongest (Farrell, Theodoros, Ward, et al. 2005; Sapir et al., 2008; Ho, Bradshaw & Iansek, 2008). By contrast the case for these therapies effecting improvement in intelligibility remains weak. They may even produce a negative outcome. Investigations of alterations in communication participation and impact related to medical and surgical interventions are largely lacking.

The limited effects of medical and surgical interventions on communication may arise from the fact that speech movement may be controlled via networks separate to limb control. The interventions and dosage levels that can improve balance and limb control may therefore not facilitate speech. Even where better underlying speech motor performance is seen, the fact that speech naturalness and intelligibility, let alone participation and impact, do not link directly to underlying tone, power, coordination, diadochokinetic rate, and similar variables, means that improvements in these will not automatically feed through to day to day communicative success.

Thus there is a major role for behavioural therapies in preventing the emergence of communication problems and in bringing about change in communicative performance. Techniques such as rate control (Yorkston, Hakel, Beukelman & Fager, 2007b), cuing (Baker, Rochester & Nieuwboer, 2008) and attention to effort (Ho et al., 1999; Sapir et al., 2008) have all proved successful in gaining better speech for people with PD. The latter technique, long practised by speech language pathologists, has more recently been applied

in the framework of the formalised Lee Silverman Voice Treatment programme (Sapir et al., 2008). To date this is the only treatment approach that has been tested out more rigorously and been shown to be effective. While ample anecdotal evidence and small scale studies support claims of the other therapy techniques, definitive confirmation of their efficacy on a larger more rigorous scale is still awaited.

PD affects pragmatic and cognitive aspects of communication. One would therefore expect therapies which target these to also improve matters. No large scale investigations exist applying these therapies in PD. There is growing evidence from neighbouring fields that they can bring about significant gains (Cardol, de Jong, van den Bos, et al. 2002; Ross & Wertz, 2003).

Whilst most speech language pathologists call for early as possible intervention and intensive treatment, again, the soundness of these beliefs remains to be proven. The call to be involved as early as possible after diagnosis should also not distract from the fact that speech clinicians have considerable expertise to offer in maintaining optimal communication even in the later stages of the illness.

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