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An investigation of co-speech gesture production during action description in Parkinson's disease

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ABSTRACT

Introduction: Parkinson's disease (PD) can impact enormously on speech communication. One aspect of non-verbal behaviour closely tied to speech is co-speech gesture production. In healthy people, co-speech gestures can add significant meaning and emphasis to speech. There is, however, little research into how this important channel of communication is affected in PD.

Methods: The present study provides a systematic analysis of co-speech gestures which spontaneously accompany the description of actions in a group of PD patients ($N = 23$, Hoehn and Yahr Stage III or less) and age-matched healthy controls ($N = 22$). The analysis considers different co-speech gesture types, using established classification schemes from the field of gesture research. The analysis focuses on the rate of these gestures as well as on their qualitative nature. In doing so, the analysis attempts to overcome several methodological shortcomings of research in this area.

Results: Contrary to expectation, gesture rate was not significantly affected in our patient group, with relatively mild PD. This indicates that co-speech gestures could compensate for speech problems. However, while gesture rate seems unaffected, the qualitative precision of gestures representing actions was significantly reduced.

Conclusions: This study demonstrates the feasibility of carrying out fine-grained, detailed analyses of gestures in PD and offers insights into an as yet neglected facet of communication in patients with PD. Based on the present findings, an important next step is the closer investigation of the qualitative changes in gesture (including different communicative situations) and an analysis of the heterogeneity in co-speech gesture production in PD.

1. Introduction

Parkinson's Disease (PD) is a progressive neurodegenerative disorder in which death of dopaminergic cells in the substantia nigra pars compacta results in motor impairments. Normal motor functioning is not only crucial for navigating through the environment; it also underpins communicative acts such as speech and facial expression.

A number of verbal communicative deficits arise in PD due to motor difficulties; abnormal articulation, prosody [1], and difficulties modulating voice pitch and loudness [2]. PD patients also exhibit non-verbal communicative deficits, specifically difficulty generating [3] and recognising [4] facial expressions. However, the umbrella term of 'communication' involves more than speech and facial expressions; importantly it also encompasses *co-speech gestures* [5].

Co-speech gestures involve movements of the hands and arms, which healthy speakers produce spontaneously and frequently while talking [6]. *Iconic* gestures, one type of co-speech gesture, represent semantic information relating to concrete concepts, while *metaphoric* gestures occur with reference to abstract concepts [6]. *Deictic gestures* are gestures with a pointing function,

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including the use of the extended index finger or the whole hand to indicate a referent [5,6]. Other gestures play important *interactive* [7] as well as *pragmatic* [5] functions in dialogue. Beats, one form of pragmatic gesture, are simple biphasic flicks of the hand providing emphasis to the verbal message and are closely tied to the rhythmical pattern of speech [6]. Overall, co-speech gestures add important information above and beyond that communicated in speech [8]. However, despite the fact that reduced bodily gestures is a recognised feature of PD [1], the domain of co-speech gestures remains largely unexplored in PD.

A small number of studies have investigated gesture production more generally in PD, reporting a reduction in gesture use [3,9]. On the one hand, this is not surprising given patients' difficulties in producing fine, simultaneous and sequential movement [10]. Moreover, reduced gestures may be expected in parallel with reduced speech in PD, considering that gesture and speech form a single system [6]. On the other hand, this close connection also means that gestures could compensate for difficulties with spoken language [11]. This process can be observed in healthy speakers, for example in the context of verbal ambiguity [12] and lexical access [13].

One limitation of previous studies into gestures in PD is that rather than considering *co-speech* gestures, they have only considered those that occur in the *absence* of speech. For example, examining pantomime movements (e.g., brushing teeth) or imitating hand gestures [14]. Indeed, Ideomotor apraxia has been observed in a proportion of PD patients (27% [15]). To date, however, only one study [3] has directly investigated the issue of co-speech gestures in PD. Their principle aim was to investigate which non-verbal cues resulted in PD patients being perceived as more 'hostile', 'anxious', 'morose', and less 'intelligent' than cardiac controls [16]. Consequently, they analysed the *silent* videotapes from this earlier study and concluded that 'gestures which commonly accompany speech' (p.182 [3],) are markedly reduced in PD patients compared to age-matched cardiac controls. However, their conclusions are limited by several factors; firstly, their analysis of silent videotapes is problematic. This is because these gestures are designed to go with speech, making reliable interpretation of people's idiosyncratic gestures [6] difficult in the absence of speech. Secondly, their categorisation of gestures included deictic gestures 'and others', namely 'all those associated with speech' (p. 180 [3],) – exactly which kind of gestures this comprised is left unspecified. Thirdly, their number of participants was very small ($N = 4$).

Therefore, the primary aims of this research were, firstly, to determine whether Parkinsonian patients gesture significantly less than age-matched controls and, secondly, to determine if any gesture type is particularly affected. Video footage was analysed of 23 patients and 22 healthy controls, describing two tasks involving everyday actions; pressing a button and turning a door handle. The co-speech gestures they produced during these descriptions were coded and analysed to answer the above research questions.

2. Methods

2.1. Participants

23 Parkinsonian patients and 22 healthy controls (Table 1) took part in this study, which was approved by the local research ethics committee. Participants consented to being video-recorded before the testing session began. All participants were screened for dementia at the start of the session using the Mini Mental State Examination [17] and scored in the normal range (>25/30). After the testing phase, but prior to video-recording, all participants completed a battery of questionnaires and standardised tests. As can be seen in Table 1, the groups did not significantly differ in age, intelligence quotient (IQ; estimated using the National Adult Reading Test [18] and the Mill Hill vocabulary test [19]), years of education, or on the Geriatric Depression Scale [20].

Patients were recruited at Hoehn and Yahr [21] stage III or less to enable them to perform the reaction time tasks. They scored a mean of 20.10 ($SD = 6.60$) on the motor subsection of the Unified Parkinson's Disease Rating Scale [22], with disease duration ranging from less than 1 up to 16 years. They completed the session "on" their normal medication, at a time of day they chose to maximise the chance of a stable on period, apart from one patient who was not yet taking medication. Twenty patients were taking L-dopa of which sixteen patients were also taking dopamine agonists. In addition, twelve patients were taking catechol-*o*-methyl-transferase, three were taking anticholinergics and three patients were taking monoamine oxidase inhibitors. 18 of the patients exhibited tremor and 10 reported experiencing dyskinesias.

2.2. Procedure

The video data for this investigation was collected at the end of a session from a previously reported experimental study [23]. Each participant sat at a 45° angle to the video-camera providing a full view of the participant's hands, arms, head and torso. They were asked to ignore the video-camera and to describe to the experimenter what they had done in the experimental session, imagining that the experimenter had been absent during the testing phase and therefore was unaware of what they had done. Briefly, in the first task, participants viewed a video clip of a blue square, or of a finger, moving up or down and were required to respond by pressing or releasing a button (Fig. 1A) when an "X" appeared onscreen. The second task involved pressing a left or right button (Fig. 1A) depending on whether an onscreen shape (a simple bar or door handle) was squared or rounded. As part of this task, participants estimated the time of real and imagined movements towards a metal door handle, mounted on a piece of wooden board and within reaching distance of the participant (Fig. 1B). After participants had described these tasks, the experimenter asked them to describe their favourite and least favourite aspect of the testing phase.

2.3. Analysis

The speech of each participant was transcribed verbatim from the video-recordings. The number of words (including word fragments and repeated words) was used to calculate their gesture rate per 100 words.

Gestural analysis included all arm, hand, finger and head movements which accompanied speech. Using the computer software ELAN (version 3.6.0), gestural movements were first identified from the video-recordings by a single coder. In most cases, the hand(s) returned to rest position after each individual gesture. When multiple gestures were produced in succession without the hand(s) returning to rest position, each stroke phase [6] was counted as one gesture. Gestures with direct verbal translation, namely emblematic gestures (e.g., 'thumbs up' gesture), as well as self-adapters (e.g., touching the hair or face [24],) were excluded as they bear a crucially different relation to speech compared to other co-speech hand movements. Each individual gesture was then classified (see Introduction) as being iconic, metaphoric, deictic, or pragmatic/interactive (combining what some authors have defined as beats, interactive and pragmatic gestures). In total, 1878 gestures were identified. Finally, the number of gestures per 100 words was calculated for each

Table 1
Characteristics of the two groups: gender, mean (SD) age, years in education, digit span, intelligence (indexed by the National Adult Reading Test, NART and Mill Hill Vocabulary Scale, MHVS) and depression (Geriatric Depression Scale).

Group	Gender	Age	Years in education	Digit span		Intelligence		Depression
				Forward	Backward	NART	MHVS	
Controls ($n = 22$)	9 male 13 female	65.0 (9.0)	13 (3)	6.7 (2.1)	5.1 (1.2)	117.4 (7.7)	23.5 (5.0)	2.4 (3.2)
PD ($n = 23$)	9 male 14 female	62.0 (8.0)	12 (3)	7.2 (1.7)	4.8 (1.7)	115.9 (7.1)	21.3 (4.4)	3.8 (2.5)
t-test	*NA*	$t = 1.06$ $p = .30$	$t = .79$ $p = .43$	$t = .112$ $p = .911$	$t = .102$ $p = .920$	$t = .350$ $p = .72$	$t = 1.36$ $p = .18$	$t = -1.47$ $p = .15$