

# Presence Hallucinations during Locomotion in Patients with Parkinson's Disease

Jevita Potheegadoo, PhD,<sup>1,2,\*</sup>  Herbertho Dhanis, MSc,<sup>1,2</sup> Judit Horvath, MD,<sup>3,4</sup> Pierre R. Burkhard, MD,<sup>4</sup> and Olaf Blanke, MD<sup>1,2,4</sup>

The presence hallucination (PH) is the sensation that somebody is nearby when no one is actually there. Affecting up to 60% of patients with Parkinson's disease (PD) and occurring early, PHs are clinically relevant for indicating potential negative clinical outcome.<sup>1–3</sup> Recently, we have induced PHs safely in patients with PD by generating sensorimotor conflicts while patients repeatedly actuated a robotic device providing tactile feedback.<sup>4</sup> Patients with symptomatic PHs were more sensitive to such sensorimotor stimulation than those without. We also identified abnormal sensorimotor processes predictive for the occurrence of PHs.

Here, we describe the case of two patients with PD who reported PHs after PD onset only when they were involved in repetitive locomotor activities in daily life—clinical evidence in favor of the importance of sensorimotor signals in PHs in PD, compatible with repetitive robotic sensorimotor stimulation inducing PH in PD.<sup>4</sup>

A 73-year old patient experienced PHs repeatedly, but only when walking outside his home. PHs are frequent and enduring, occurring several times per week: “*I'm walking, then I feel that someone is just behind me, a bit on my right, wanting to overtake me, bending over my shoulder. This person seems to walk faster than me, just two steps behind. I stop quickly, and move sideways for this person to pass, but when I look behind, there's no one*”. The patient also described passage hallucinations<sup>2</sup> and somatosensory hallucinations, but all as occurring outside locomotion periods.

Another 79-year old patient experienced two distinct PHs, one positive (*guardian angel*) and one negative PH, occurring independently from each other several times per month, only during walking. The patient has the impression of someone behind her, close (1 m), on the right side, next to her shoulder, as if someone is “*catching up*” with her. The positive PH lasts for a few seconds only, the negative PH somewhat longer. The patient would step sideways to let the “*person*” pass but there is no one. Passage hallucinations and visual illusions occur occasionally, but always outside locomotion periods.

The repeated occurrence of PHs during locomotion in these two patients, and not in other situations, suggests that sensorimotor processing related to gait plays a functional role in PH. We argue that for some patients with PD, locomotion—a highly procedural motor activity associated with tactile and proprioceptive feedback—facilitates PHs by interfering with sensorimotor processes.<sup>4</sup> A widespread network including cerebellum, cortical and sub-cortical structures is involved in locomotion and integration of related sensorimotor signals, for which the role of the basal ganglia has particularly been emphasized.<sup>5</sup> Partly similar brain regions were recruited in robot-induced PHs,<sup>4</sup> suggesting a neural overlap between gait control and PHs. We note that both patients did not suffer from dementia, nor delusions (Table 1). PHs were unrelated to recent changes in medication.

<sup>1</sup>Center for Neuroprosthetics, Faculty of Life Sciences, Swiss Federal Institute of Technology (EPFL), Geneva, Switzerland; <sup>2</sup>Brain Mind Institute, Faculty of Life Sciences, Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland; <sup>3</sup>Neurology Center, La Tour Hospital, Meyrin, Switzerland; <sup>4</sup>Department of Clinical Neurosciences, Geneva University Hospital, Geneva, Switzerland

\*Correspondence to: Dr. Jevita Potheegadoo, Center for Neuroprosthetics & Brain Mind Institute, School of Life Sciences, Campus Biotech, Ecole Polytechnique Fédérale de Lausanne (EPFL), Chemin des Mines, 9, 1202 Geneva, Switzerland, E-mail: jevita.potheegadoo@epfl.ch

**Keywords:** Parkinson's disease psychosis, non-motor symptoms, illusions, sensorimotor processing, procedural activities.

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

Received 17 May 2021; revised 13 October 2021; accepted 19 October 2021.

Published online 11 November 2021 in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/mdc3.13367

**TABLE 1** Socio-demographic information, clinical data and medications of the two patients with Parkinson's disease (PD)

	Case 1	Case 2	
Socio-demographic data			
Age (years)	73	79	
Sex	M	F	
Level of schooling (years)	9	12	
Handedness	Right	Right	
Clinical characteristics of PD			
Duration of PD (years)	14	7	
Symptoms lateralization (onset)	Right	Left	
UPDRS 1	16/52	15/52	
UPDRS 2	19/52	15/52	
UPDRS 3	19/124	18/124	
UPDRS 4	1/24	0/24	
Medications			
Levodopa equivalent daily dose (including dopamine agonists) (mg/day)	1180	1900	
<b>Neuropsychological tests</b>			<b>Cut-off scores</b>
MoCA	26	27	< 26/30
PD-CRS (total score)	73a	102	≤ 81/134
Fronto-subcortical score (executive functioning)	43	72	
Posterior cortical score	30	30	
Occurrence of hallucinations			
Presence hallucinations (PH)	✓	✓	
Passage hallucinations	✓	✓	
Visual illusions (eg, pareidolia)	✓	✓	
Visual hallucinations	×	×	
Auditory hallucinations	×	✓	
Somatosensory hallucinations	✓	×	
Olfactory/gustatory hallucinations	×	×	

<sup>a</sup>Scores below normal range.

✓ presence of hallucination.

× absence of hallucination.

UPDRS, Unified Parkinson's disease rating scale; MoCA, Montreal Cognitive Assessment; PD-CRS, Parkinson's disease-Cognitive Rating Scale.

Future research in patients with PD investigating the impact of ongoing locomotor activity on altered sensory perceptions is needed and may reveal that PHs during locomotion are more frequent than commonly thought.

Wicki, Dr. Fosco Bernasconi and Dr. Oliver A. Kannape for their review and critique of the manuscript.

## Acknowledgments

The authors are grateful to the two patients for their time and for sharing their subjective experience of hallucinations with us. We also thank Prof. Paul Krack, Prof. Ghika, Dr. Benoît

## Author Roles

(1) Research project: A. Conception, B. Organization, C. Execution; (2) Statistical Analysis: A. Design, B. Execution, C. Review and Critique; (3) Manuscript Preparation: A. Writing of the first draft, B. Review and Critique.

J.P.: 1A, 1B, 1C, 3A.

H.D: 1B, 2C, 3B.  
J.H: 1C, 3B.  
P.B: 1C, 3B.  
O.B: 1A, 3A, 3B.

## Disclosures

**Ethical Compliance Statement:** We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this work is consistent with those guidelines. The two patients were recruited in Switzerland from La Tour Hospital (Geneva) and Geneva University Hospital and were identified in the setting of an ongoing study on hallucinations in PD. The patients gave written informed consent prior to participating in the study approved by the local ethics committee of the *Commission cantonale d'éthique de la recherche (CCER)* of Geneva (protocol n° 2019–02275).

**Funding Sources and Conflicts of Interest:** The present observational report is part of a larger research project investigating hallucinations in Parkinson's disease. This project was supported by two generous donors advised by CARIGEST SA, the first one wishing to remain anonymous and second one being *Fondazione Teofilo Rossi di Montelera e di Premuda*; Bertarelli

Foundation; Swiss National Science Foundation [grant number FNS 320030\_188798], Parkinson Schweiz Foundation ; Empiris foundation (grant number 532305) and Novartis Foundation [grant number 20A054]. The authors report no conflict of interest.

**Financial Disclosures for the Previous 12 Months:** The authors declare that there are no additional disclosures to report. ■

## References

1. Lenka A, George L, Arumugham SS, et al. Predictors of onset of psychosis in patients with Parkinson's disease: who gets it early? *Parkinsonism Relat Disord* 2017;44:91–94.
2. Ffytche DH, Creese B, Politis M, et al. The psychosis spectrum in Parkinson disease. *Nat Rev Neurol* 2017;13(2):81–95.
3. Fénelon G, Soulas T, De Langavant LC, Trinkler I, Bachoud-Lévi A-C. Feeling of presence in Parkinson's disease. *J Neurol Neurosurg Psychiatry* 2011;82(11):1219–1224.
4. Bernasconi F, Blondiaux E, Potheegadoo J, et al. Robot-induced hallucinations in Parkinson's disease depend on altered sensorimotor processing in fronto-temporal network. *Sci Transl Med* 2021;13(591):eabc8362. Available from: <https://stm.sciencemag.org/content/13/591/eabc8362>.
5. Takakusaki K. Functional neuroanatomy for posture and gait control. *J Mov Disord* 2017;10(1):1–17.