Narrowing wide-field optic flow affects treadmill gait in left-sided Parkinson's disease

van der Hoorn, Anouk; Hof, At L.; Leenders, Klaus L.; de Jong, Bauke M.

Published in:
Movement Disorders

DOI:
10.1002/mds.24011

Publication date:
2012

Narrowing wide-field optic flow affects treadmill gait in left-sided Parkinson's disease.

Anouk van der Hoorn (BSc)[1], At L. Hof (MSc, PhD)[2, 3],

Klaus L. Leenders (MD, PhD)[1], Bauke M de Jong (MD, PhD)[1]

[1] Department of Neurology, University Medical Centre Groningen, University of Groningen, the Netherlands.
[2] Centre for Human Movement Science, University of Groningen, the Netherlands.
[3] Centre for Rehabilitation, University Medical Centre Groningen, the Netherlands.

Corresponding author:

A. van der Hoorn, BSc.,
Department of Neurology,
University Medical Centre Groningen,
Hanzeplein 1,
P. O. Box 30.001,
9700 RB Groningen,
The Netherlands.
Telephone: +31 50 361 2400,
Fax: +31 50 361 1707
E-mail: a.van.der.hoorn@neuro.umcg.nl

Total word count: 492

Running title: Optic flow influences gait in Parkinson

Potential conflict of interest: None.

Financial disclosure: The study was supported by a Junior Scientific Masterclass grant of the University of Groningen.

Keywords: Parkinson's disease; optic flow; freezing of gait; visuomotor transformation; treadmill walking.

LETTER TO THE EDITOR

Radially expanding optic flow is a visual consequence of forward locomotion and supports walking, also in patients with Parkinson's disease (PD) (1). When presented on a display, it evokes the illusion of forward self-motion. This implies that manipulation of optic flow while walking on a treadmill enables testing the effect of this basic stimulus pattern on gait progression, independent from actual walking. As movements in PD patients are more vulnerable to external stimuli, which may lead to e.g. freezing of gait (FOG), we expected a stronger effect of manipulating optic flow in these patients than in healthy control (HC) (2).

Fifteen PD patients (8 right-sided symptom dominance (PD.R), 7 left-sided (PD.L)) and 10 matched HC (mean age 66.3 yrs, SD 7.8) were tested. Patients (aged 64.9 yrs, SD 7.7) were mildly affected (Hohn & Yahr 2.3; UPDRS III 24.3 (SD 7.6)) and did not suffer from FOG. At steady-speed walking on the treadmill, narrowing the optic flow field was expected to evoke slowing of gait with backward displacement, mimicking the effect of approaching a narrow corridor. The latter was quantified by centre of mass calculation (3). Optic flow was presented by white dots in the lower half of a black screen (171x128cm). A gradual 1.8s transition from a wide to narrow flow field occurred by expanding dark grey surfaces from the horizon in both upward and downward directions (condition Fw-to-Ftn), which provided the natural illusion of moving into the changing environment (4). Control conditions for non-specific visual effects were the abrupt transition from wide flow to stationary dots (Fw-to-Sw) and gradual transition from a wide to narrow stationary field (Sw-to-Stn), respectively. Given right-hemisphere dominance in visuospatial processing, stronger effects were expected in PD.L (5). The WAIS block design test was used as general indicator of right hemisphere function.

The transition of narrowing the wide optic flow field evoked clear gait obstruction in particularly PD.L (figure 1). This suggested a relation with right hemisphere dysfunction, which was supported by the correlation between stronger gait obstruction and lower scores on the WAIS block design in the entire PD group ($p_{one\text{-}tailed}$=0.016, r=-0.552).

Although patient numbers were rather small after splitting into PD.L and PD.R groups, the novel paradigm of manipulating optic flow during treadmill gait appears to provide a promising strategy to study the effects of basic visual stimulus features on gait control. The effect in particularly PD.L is consistent with right-hemisphere dominance concerning visuomotor transformations, also in gait (5-6). Enhanced stimulus effects on movements in PD may be a consequence of reduced output from basal-ganglia-thalamic circuitry to the lateral premotor cortex leaving an overruling effect of parietally transferred visual information. As the output of basal-ganglia-thalamic circuitry to medial frontal regions may be even more affected (7), interference of gait by external stimuli is complemented by a failure to keep this movement pattern going by internal drives (8). This medial-lateral distinction is supported by our recent functional MRI study in healthy subjects showing a shift from lateral to medial premotor cortices when wide-field optic flow transited into a narrow flow field (4).

ACKNOWLEDGMENTS

We like to thank Prof. E. Otten and Dr. R. B. Huitema for general advice regarding concepts of designing the study and Ing. W. A. Kaan for developing the LabVIEW software. The study was supported by a Junior Scientific Masterclass grant of the University of Groningen.

AUTHORS' ROLES

A. van der Hoorn: Conception, organization and execution of the research project; Design and execution of statistical analysis; Writing of the first draft of the manuscript. A.L. Hof: Conception of the research project; Design of statistical analysis; Review and critique of manuscript. K.L. Leenders: Conception of the research project; Review and critique of manuscript. B.M. de Jong: Conception and organization of the research project; Review and critique of statistical analysis; Review and critique of manuscript.

FINANCIAL DISCLOSURE FOR THE PAST YEAR.

Ms Van der Hoorn received a Junior Scientific Masterclass grant of the University of Groningen. Prof. dr. Hof, prof. dr. Leenders and dr. De Jong report no disclosure.

REFERENCES

(1) Azulay JP, Mesure S, Amblard B, Blin O, Sangla I, Pouget J. Visual control of locomotion in Parkinson's disease. Brain 1999;122:111-120.

(2) Cowie D, Limousin P, Peters A, Day BL. Insight into the neural control of locomotion from walking through doorways in Parkinson's disease. Neuropsychologia 2010; 48: 2750-2757.

(3) Verkerke GJ, Hof AL, Zijlstra W, Ament W, Rakhorst G. Determining the centre of pressure during walking and running using an instrumented treadmill. J Biomech 2005;38:1881-1885.

(4) van der Hoorn A, Beudel M, de Jong BM. Interruption of Visually Perceived Forward Motion in Depth evokes a Cortical Activation Shift from Spatial to Intentional Motor Regions. Brain Res 2010;1358:160-171.

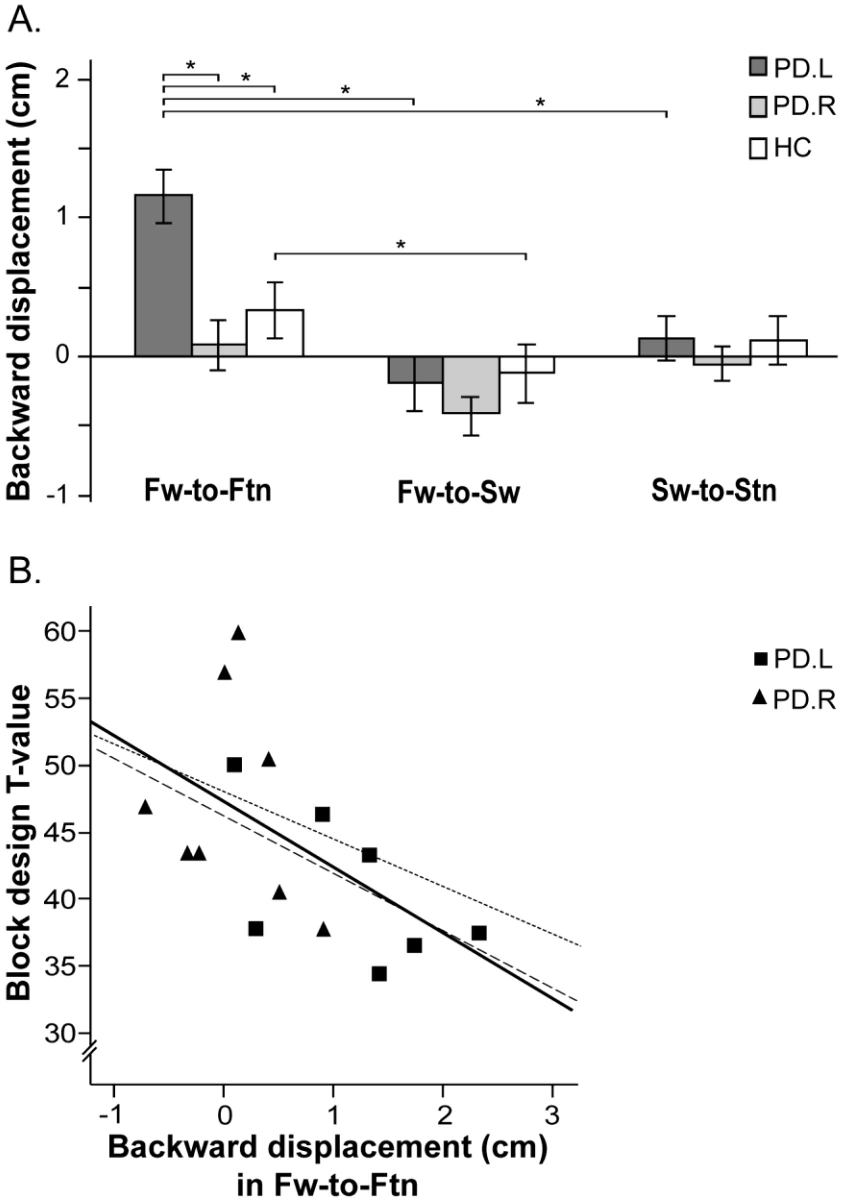
(5) Bartels AL, de Jong BM, Giladi N, et al. Striatal dopa and glucose metabolism in PD patients with freezing of gait. Mov Disord 2006;21:1326-1332.

(6) Davidsdottir S, Wagenaar R, Young D, Cronin-Golomb A. Impact of optic flow perception and egocentric coordinates on veering in Parkinson's disease. Brain 2008;131:2882-2893.

(7) Jenkins IH, Fernandez W, Playford ED, Lees AJ, Frackowiak RSJ, Passingham RE, Brookds DJ. Impaired activation of the supplementary motor area in Parkinson's disease is reversed when akinesia is treated with apomorphine. Ann Neurol 1992;32:749-757.

(8) Rushworth MFS. Intention, choice, and the medial frontal cortex. Ann N Y Acad Sci 2008;1124:181-207.

FIGURE 1.



Effect of narrowing optic flow on treadmill position and correlation with block design test.

A. Mean backward displacement on the treadmill (with standard error) is expressed by positive values (in cm), comparing the mean position in the 1.8s frame after- and 1.8s before transition onset in the visual display (* $p<0.05$).

B. Right-hemisphere involvement in backward displacement of Parkinson patients during treadmill gait is expressed by the correlation between the block design test and the effect of the transition from a wide to narrow forward optic flow field (Fw-to-Ftn). The thick line shows the overall regression, $R^2 = 0.305$. The separate regression lines for PD.L and PD.R patients are constituted by thin dashes and dots, respectively.

Abbreviations: PD.L = Parkinson's disease with left-sided symptom dominance; PD.R = PD with right-sided symptom dominance; HC = Healthy controls; Fw-to-Ftn = transition from wide flow-field to narrow flow; Fw-to-Sw = control transition of wide flow to stationary wide field; Sw-to-Stn = control transition of stationary wide field to stationary narrow field; cm = centimeter.