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A Note of Caution on Distorted Visual Feedback as a Treatment for Functional Movement Disorders

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There has been considerable interest in virtual reality (VR) and augmented reality as useful tools in neurorehabilitation (1). This interest has extended recently to functional movement disorders (FMD) (2). VR has potential relevance to FMD rehabilitation for several reasons, including its effectiveness in modification of beliefs and attention diversion. However, despite the rationale for its use, recent data that we have collected using distorted visual feedback in FMD suggest a note of caution.

The study comprised 23 people with a functional action tremor (12 females, age *M*=52.3y, *SD*=14.8y) and two age- and gender-matched control groups: 22 organic action tremor patients and 23 healthy controls. Participants moved their fingertip on a touchpad from a starting position to a target (4.5mm circle) 24cm straight ahead. Their arm was hidden underneath a horizontal screen displaying the start, the target and their current fingertip position. After >250 reaching movements described by the authors previously (3), participants performed another 10 baseline trials ("baseline-pre" condition). Then they were told that all their previous trajectories' average shakiness had been computed. Henceforth, if shakier than their average, the computer would smooth out their visual feedback, so that the displayed cursor path resembled their average. If their trajectory was similar or better than their average, it would be displayed unchanged. In order to make them believe that on average they had little tremor, the visual feedback was actually always smoothed out by dividing each x coordinate by 3 ("smooth" condition). After 20 such trials, the smoothing was removed without notice and another 10 baseline trials were performed ("baseline-post" condition). Comparing the pre-baseline with the smooth condition evaluated whether attenuated visual feedback of lateral displacements during reaching reduced actual lateral movements, including tremors. Comparing the pre- versus post-baseline conditions assessed whether such altered visual feedback and beliefs had persistent effects.

Although in healthy controls the trajectories became straighter and faster during the "smooth" condition, this effect was not significant in either patient group, and even in healthy controls did not persist (Table 1).

Artificially smoothing visual feedback did not lead to improvement in functional tremor; neither during nor after a feedback session. While it is possible that benefits might be seen with more realistic, longer or more intense training, we believe that these data sound a note of caution about the use of distorted feedback and hence VR in FMD treatment.

Rather than using distorted feedback, established FMD physiotherapy often uses full-length mirrors to divert attention away from the body, while simultaneously providing veridical feedback allowing correction of the abnormal movement pattern (4). We hypothesise that VR could be detrimental, particularly if abnormal movements occur but veridical visual feedback of the abnormality is suppressed by VR. This may reinforce the abnormal movement pattern as a seemingly normal movement. It may lead to a similar situation to that seen in fixed dystonia: in the absence of direct vision , patients perceive their limb to be in a normal position, when in reality it is not. (5). Careful exploratory investigations of 'Normalising VR' in people with FMD are required before moving to clinical trials.

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Authors' roles

1) Research project: A. Conception, B. Organization, C. Execution;

2) Statistical Analysis: A. Design, B. Execution, C. Review and Critique;

3) Manuscript: A. Writing of the first draft, B. Review and Critique, C. Final version

A-CH: 1A, 1B, 1C, 2A, 2B, 3A, 3C

PH: 3B

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Ethical Compliance Statement

The study was approved by the local ethics committee (London-Bromley Research Ethics Committee, reference: 16/LO/1463), and participants gave their written, informed consent. 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.

Data availability

Our ethics agreement prevents data being openly available, but individual researchers may request deidentified participant data from the corresponding author.

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Table 1: Path lengths and durations for the different conditions with the respective statistical analyses

		Baseline-pre Mean (*SD*) (median)	**Smooth** Mean (*SD*) (median)	**Baseline-post** Mean (*SD*) (median)	**Friedman´s test**	**Baseline-pre versus Smooth** Wilcoxon signed-rank test	**Baseline-pre versus Baseline-post** Wilcoxon signed-rank test
Healthy controls (N=23)	**Path length** (in pixels)	810 (11.0) (808)	802 (6.2) (801)	811 (13.4) (808)	χ^2 (2) = 12.87 **p = .002** W = .28	Z = 3.53 **p_{corr} = .0008** r = .74	Z = -0.52 p_{corr} = .61 r = -.11
	Duration (in ms)	1684 (591) (1522)	1491 (569) (1432)	1606 (547) (1444)	χ^2 (2) = 7.91 **p = .019** W = .17	Z = 3.25 **p_{corr} = .002** r = .68	Z = 1.58 p_{corr} = .11 r = .33
Organic tremor (N=22)	**Path length** (in pixels)	810 (11.6) (806)	804 (9.2) (802)	811 (9.1) (809)	χ^2 (2) = 8.27 **p = .016** W = .19	Z = 2.19 p_{corr} = .056 r = .47	Z = -0.93 p_{corr} = .35 r = -.20
	Duration (in ms)	2017 (556) (1953)	1942 (768) (1755)	1901 (638) (1701)	χ^2 (2) = 1.91 p = .39 W = .043		
Functional tremor (N=23)	**Path length** (in pixels)	855 (138.8) (814)	841 (73.5) (813)	834 (48.3) (816)	χ^2 (2) = 2.70 p = .26 W = .059		
	Duration (in ms)	3359 (1753) (3054)	3573 (1915) (3194)	3492 (1800) (3422)	χ^2 (2) = 1.65 p = .44 W = .036		

Direct path length: 792 pixels. Given non-normality / unequal variances, Friedman´s rank test, and if significant Wilcoxon signed-rank tests were performed. For pairwise comparisons, p-values were Šidák-Holm corrected for multiple comparisons (p_{corr}). Effect size estimates: Kendall´s W and Pearson´s r. Significant results ($p<.05$, two-tailed) are in bold.