Non-invasive intervention for motor signs of Parkinson's disease: the effect of vibratory stimuli

In recent years there has been a renewed interest in the use of peripheral vibration to ameliorate some of the motor symptoms of Parkinson's disease (PD). The possibility that peripheral vibration can improve patients' motor symptoms is exciting as the intervention is non-invasive and of low cost. However, there remains little published scientific research to support some of the claims. Previously we demonstrated that vibration at 80 Hz at the wrist for 30 s prior to movement onset improved motor performance in a variety of manual tasks both in healthy controls and in patients with PD.[1] Here we report the results of testing whether a wearable haptic device (the 'Emma Watch') developed by Microsoft Research,[2] which delivers constant vibratory stimuli at the wrist, significantly improves motor function of the stimulated upper limb in patients with PD.

The Emma Watch delivers constant vibration at 200 Hz through six small electromagnetic mechanical stimulators, three on each side of the wrist. The vibration frequency is modulated by a lower frequency, either 20 bpm (beats per minute) or 60 bpm. These modulation parameters were based on the parameter that improved motor function in the first tested patient with PD (60 bpm) and on a parameter that did not (20 bpm). Here we tested whether the Emma Watch could improve motor function in 16 patients with PD (11 women, mean age=63 years, range 52–72 years, Unified Parkinson's Disease Rating Scale (UPDRS) III Right Upper Limb (RUL) 7±3, with disease duration of 10.5±6 years and with an average daily dose of levodopa of 500 mg). Idiopathic PD was diagnosed according to the UK Parkinson's Disease Society Brain Bank criteria[3] and further confirmed by abnormal dopamine transporter single-photon emission computed tomography (SPECT). None of the subjects was on any non-PD medications (psychotropic medications) that could affect the measurements performed. All patients were assessed in the ON state, which was evaluated an hour after taking levodopa and 2 hours of taking dopamine agonists. Written informed consent was obtained from all participants.

Motor performance was assessed through three different tasks: (1) a nine-peg hole test[4]; (2) a STAR tracing task; and (3) a SPIRAL tracing task. For task 1, subjects were instructed to place nine pegs into nine holes as quickly as possible while they were timed with a stopwatch. Subjects performed tasks 2 and 3 using an inking digitiser pen on a WACOM Intuos Pro L digitising tablet with 8192 pressure levels and a resolution of 5080 lines per inch. An inhouse Windows application recorded the WACOM data (pen x/y coordinates and pressure level) into a log file along with the beginning and end timestamps for each task.

For both tracing tasks (STAR and SPIRAL) subjects were instructed to trace the figure on a sheet of paper placed on top of the tablet surface as precisely and quickly as possible. Participants were instructed to complete the STAR task starting from the centre going to the edge and then back, beginning with the line at 90° (up) and then moving clockwise. The SPIRAL task started from the centre. Each set of three tasks was repeated in three different conditions in a randomised order: absence of vibratory stimuli (NoVib); during 200 Hz vibration with 60 bpm modulation (200Hz60bpm); and during 200 Hz vibration with 20 bpm modulation (200Hz20bpm). The order of the tasks was randomised across participants so there was no order effect. Each task and each condition were repeated three times.

The nine-hole peg test was performed both with Emma Watch (NoVib, 200Hz60bpm, 200Hz20bpm) and an electromagnetic mechanical stimulator (80 Hz vibratory stimuli) used in the previous study.[1]

The following dependent variables were recorded for each motor task:

- Nine-peg hole test: corrected mean completion time of the test (in seconds).
- STAR tracing task and SPIRAL tracing task: the average of the absolute error from the target at every time point.

For the nine-hole peg test, a repeated-measures analysis of variance (ANOVA) with one factor condition with four levels (NoVib, 200Hz60bpm, 200Hz20bpm and 80 Hz) revealed a significant main effect of the condition on the mean completion time of the nine-peg hole test ($F(3,45)=3.8$, $p=0.016$, $eta^2=0.202$; figure 1A). Post-hoc pairwise comparisons revealed a significant difference in mean completion time between 80 Hz and NoVib ($p<0.01$, $t(15)=-3.58$). These results replicated the previous study using the same device and task.[1] There was evidence of a significant difference in mean completion time between 200Hz60bpm

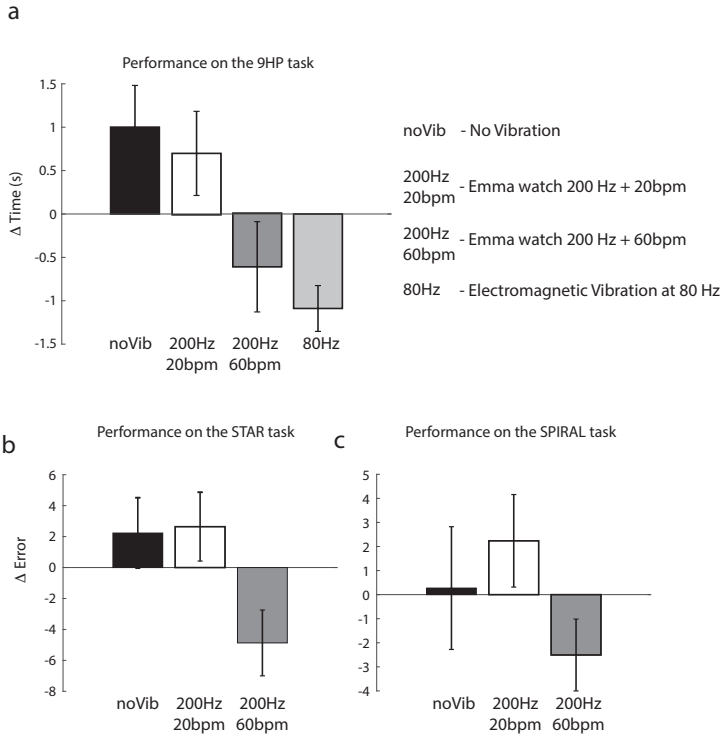

Figure 1 Averaged data for the three different tasks tested in this study: (A) nine-hole peg (9HP) task, (B) STAR task and (C) SPIRAL task. The bars show the difference from the mean across all conditions for each task (ie, if there was no modulation, the bars would be at 0, thus removing between-subject variance). Error bars are SEM. bpm, beats per minute.

and NoVib (one-tailed predicted direction; p=0.05, t(15)=1.713). There was no significant difference in mean completion time between 80 Hz and 200Hz60bpm (p=0.36, t(15)=0.941). There was no significant difference in mean completion time between 200Hz20bpm and NoVib (p=0.69, t(15)=0.412). Therefore, for the nine-hole peg test we first replicated our previous result and provided preliminary evidence that continuous vibration with the Emma Watch at 200Hz60bpm improved motor performance.

For the STAR tracing task, a repeated-measures ANOVA factor condition with three levels (NoVib, 200Hz60bpm, 200Hz20bpm) showed a main effect of condition ($F(2,30)=3.65$, p=0.037, $eta^2=0.19$; figure 1B). The Emma Watch reduced error in the 200Hz60bpm compared with both NoVib and 200Hz20bpm (one-tailed tests; t(15)=1.86, p=0.041 and t(15)=2.03, p=0.03, respectively).

For the SPIRAL tracing task, there was no main effect of condition ($F(2,30)=0.91$, p=0.41, $eta^2=0.06$; figure 1C). However, the Emma Watch did show reduced error in the 200Hz60bpm compared with 200Hz20bpm (one-tailed tests; t(15)=2.05, p=0.029) but not when compared with NoVib (one-tailed test; t(15)=0.75, p=0.23).

Our study aimed to test the impact of the non-invasive intervention device 'Emma Watch' on motor performance in patients with PD. We found that 200 Hz peripheral vibration at 60 bpm modulation applied during the performance of different tasks of a total of 16 patients with PD on medication improved performance related to movement speed as well as precision of performance on our tracing motor control tasks. In contrast, peripheral vibration at 200 Hz with 20 bpm had no significant effect on motor performance. These data, although preliminary, are consistent with the idea that vibrotactile stimulation can improve motor function in patients with PD, but further work is required now to establish these findings and investigate the relationship further.

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Contributors AM, CH, HZ, JK designed the experiment. AM, JK performed data acquisition. AM, CH, JK analysed the data. DC, JV, JM, GS, NV, HZ built the Emma Watch. AM, NP, TF, PK, PL, HZ, JK wrote the manuscript.

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