Assessing and Predicting Efficacy of Dance Intervention for Parkinson's Disease

Anna Krotinger[1] and Psyche Loui[1,2], [1]Wesleyan University, [2]Northeastern University

Introduction

Parkinson's disease (PD) is associated with a loss of internal cueing systems, which affects rhythmic motor tasks such as walking, as well as the processing of musical rhythm (Grahn 2009). Rhythmic stimulation has been shown to improve motor deficits in some patients (Bella et al. 2017); these findings have inspired dance therapies for PD (Hackney and Earhart 2009; Rehfeld et al. 2018). One emergent property of rhythm is musical groove, which is related to ease of sensorimotor coupling in simple tapping tasks (Janata et al. 2008). We wanted to see how people with PD who attend weekly Dance for PD® classes respond to differing levels of musical groove. Dance has been shown to benefit the symptoms of PD (de Natale et al. 2017, Hulbert et al. 2017, Sharp and Hewitt 2014), but it is unknown whether these effects are modulated by groove and sensorimotor experience, and if previous experience with music and dance affect these relationships.

Dance for PD® class in Brooklyn, NY.

http://www.santafenewmexican.com/pasatiempo/performance/powering-through-parkinson-s-mark-morris-dance-for-pd/article_d6841f4b-45e8-5518-b06a-c459f9921fa5.html

Aim

We tested the hypothesis that groove and sensorimotor experience, as quantified by participants' dance and music experience affect changes in Parkinsonian symptom severity following a dance intervention for PD.

Methods

Participants with PD (n=30) and members of the control group (n=19) were recruited from Dance for PD® classes in Manhattan, NY, Brooklyn, NY, San Rafael, CA, and Santa Rosa, CA. Inclusion criteria for the PD group include a Parkinson's diagnosis and consistent weekly attendance of Dance for PD® classes. Participants were interviewed twice: the first to establish a baseline and then the second, four months later, to measure any changes in symptom severity. Information about music and dance experience was obtained through a questionnaire. The IRB of Wesleyan University approved the protocol, and participants provided written informed consent.

Sensorimotor Experience

The Beat Alignment Test (BAT) (Iversen et al. 2008) was used to test auditory beat perception. In order to test sensorimotor coupling, participants completed a tapping task in which they tapped to four songs with high groove ratings and four with low (Janata et al. 2012). The variance of the inter-onset interval (IOI) between taps during the task was calculated using the mirtoolbox (Lartillot and Toiviainen 2007) in MATLAB to determine the quality of sensorimotor coupling.

Therapeutic Outcome

Therapeutic outcome was measured by rating the severity of the participant's disease at both baseline and four months using the Unified Parkinson's Disease Rating Scale (UPDRS). Pre- and post-intervention scores were then compared.

R was used to compare UPDRS and BAT scores, groove, music and dance experience, and tapping task performance.

	PD	CONTROL
SEX	Male=7, Female=23	Male=8, Female=11
AGE	Mean=72.7, SD=7.27	Mean=72.6, SD=8.95
MUSIC EXP	N(yes)=19, N(no)=11	N(yes)=11, N(no)=8
YEARS OF MUSIC	N=19, mean=23.8, SD=22.6	N=11, mean=20, SD=22.2
DANCE EXP	N(yes)=20, N(no)=10	N(yes)=12, N(no)=7
YEARS OF DANCE	N=20, mean=7.4, SD=7.6	N=12, mean=16, SD=15.1
UPDRS (initial)	N=30	N/A
BAT (intial)	N=30	N=19
TAPPING TASK (initial)	N=30	N=19
FOLLOW-UP INTERVIEW	N=20	N/A

Comparison of PD and Control groups for sex, age, music and dance experience, years of music and dance experience, completion of UPDRS, completion of BAT, completion of the tapping task, and completion of the follow-up interview.

Results: UPDRS Improvement
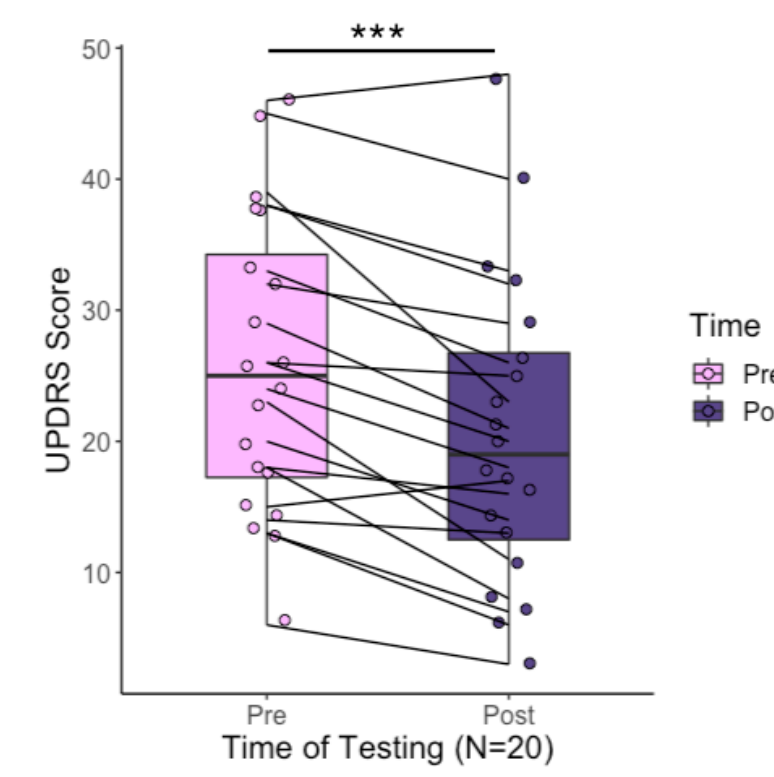
Comparison of pre- and post-intervention UPDRS scores for the 20 PD participants who completed both interviews (Paired t-test: t=4.81, df=20, p=0.000106***). Eighteen of the twenty participants who participated in the follow-up interview exhibited either preserved or improved UPDRS scores.

Beat Alignment Test (BAT)

Boxplots of d' in BAT performance. *Top two graphs*: d' plots for PD participants separated by ME (left) and DE (right). *Bottom graphs*: d' plots for the control group, again separated by ME and DE. PD participants with ME performed significantly better on the BAT performance than PD participants without it [F(1,28)=5.37, p=0.0281*], suggesting that BAT performance was modulated by previous music experience only in the setting of PD.
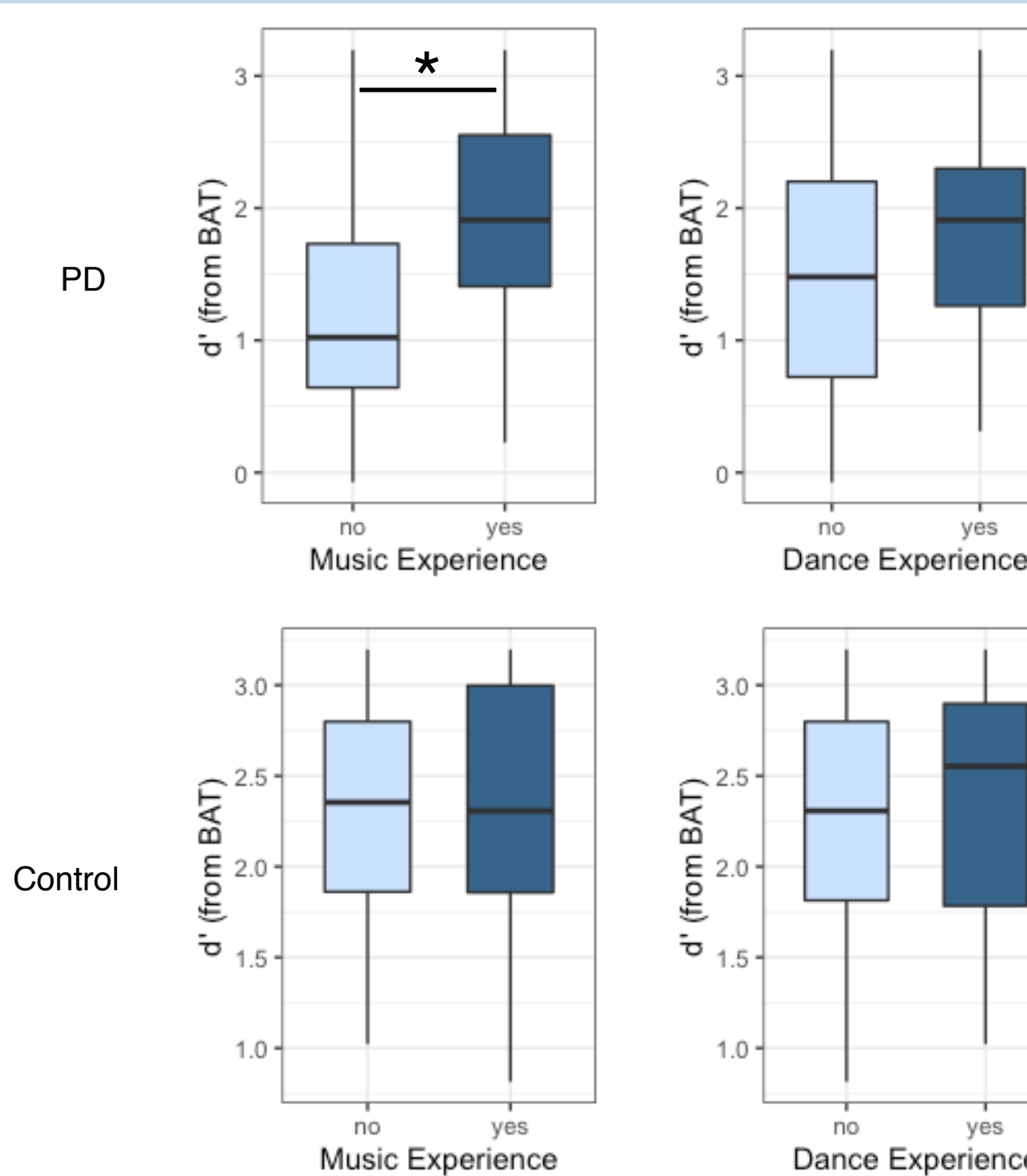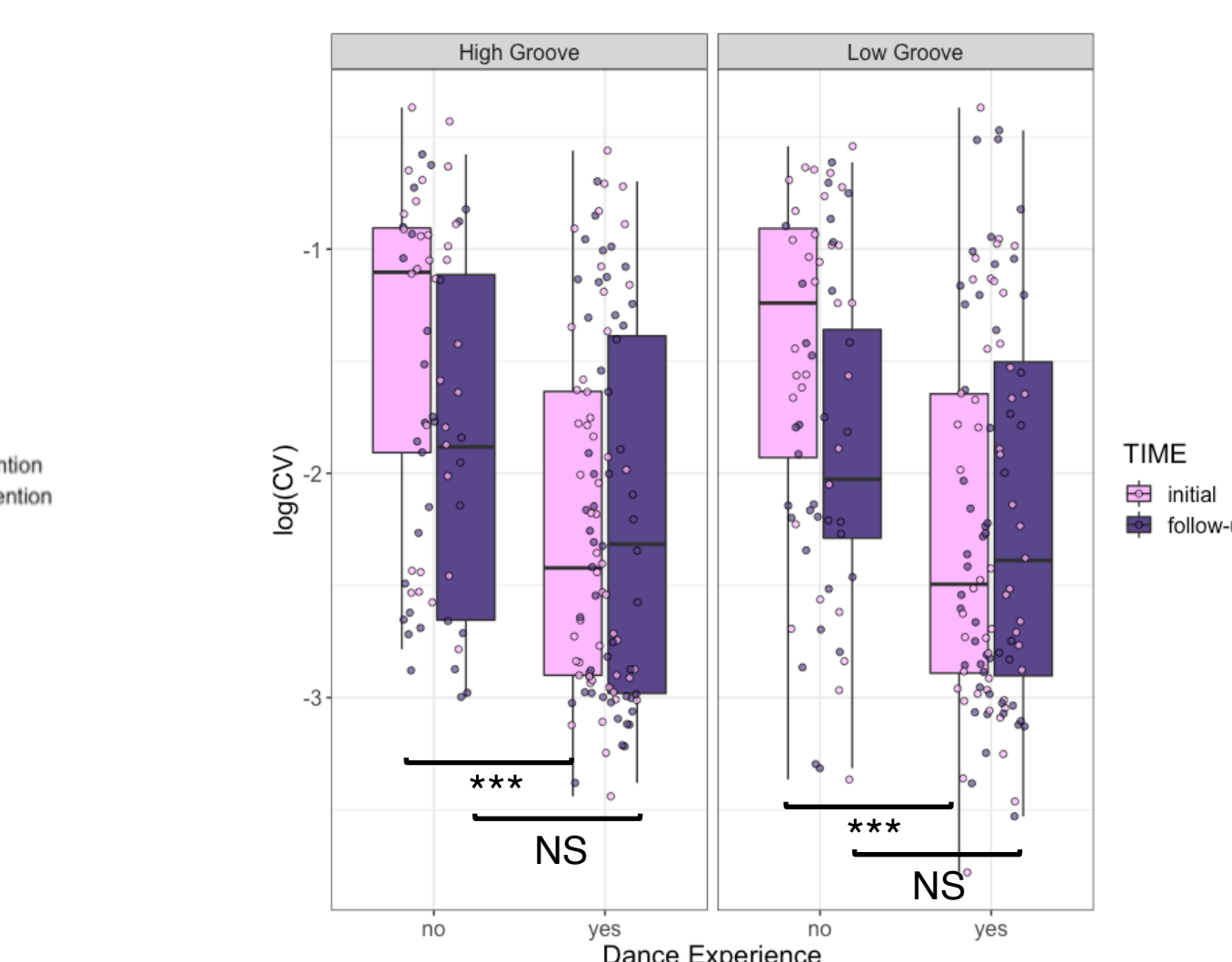

Tapping Task (Sensorimotor Coupling Ability)
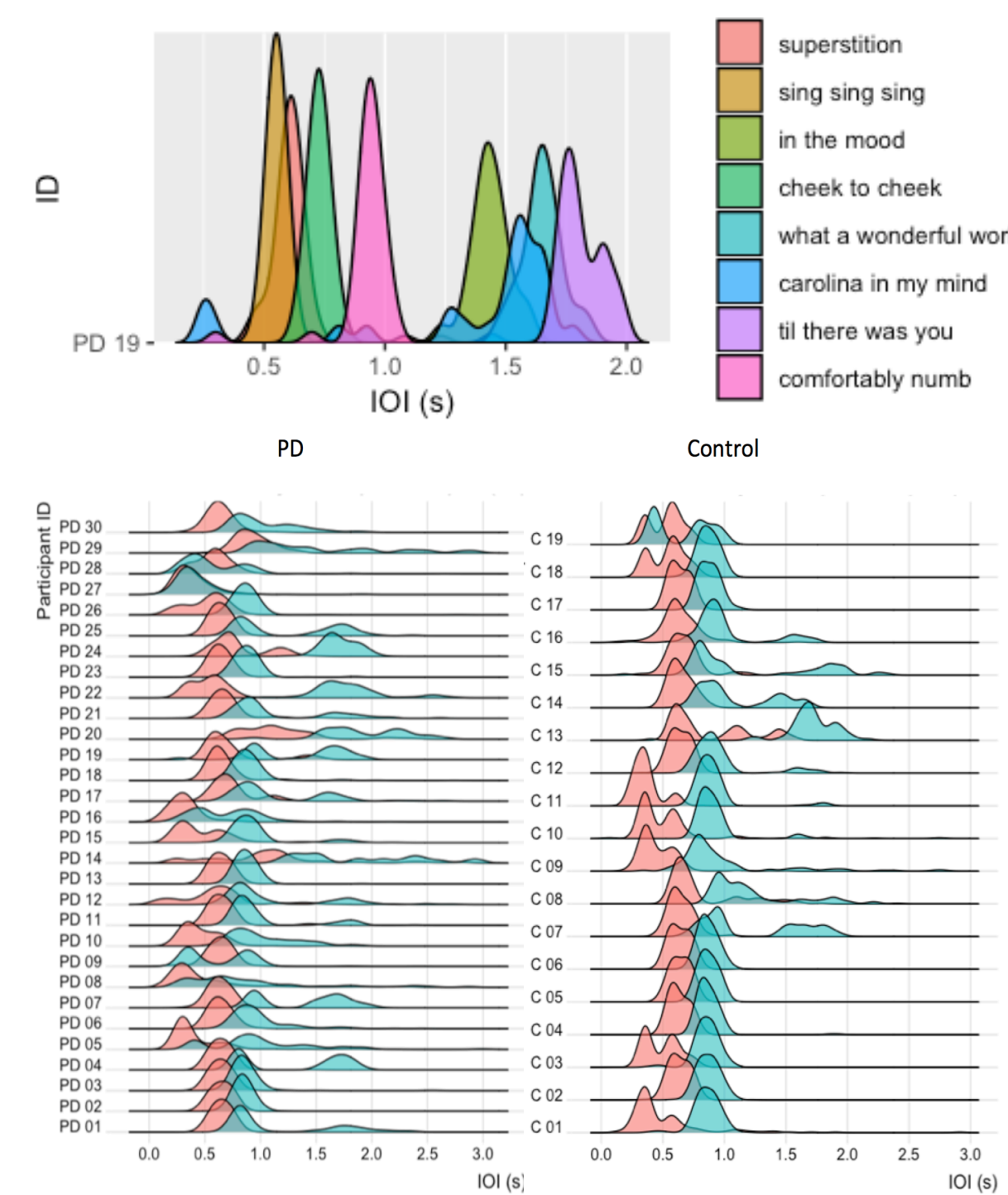
Top: Example ridgeline plot of the distributions of one PD participant's tapping to each song. *Bottom*: Ridgeline plots showing the distribution of the inter-onset interval (IOI) for each participant's tapping performance separated by groove. *Left*: Distribution of PD participants' IOI values separated into either high or low groove. *Right*: Distribution of IOI values for members of the control group separated into high and low groove. One-way ANOVA reveals that tapping to high groove songs results in significantly smaller IOI values than tapping to low groove songs for both PD [F(1,10342)=2779, p<2E-16***] and control groups [F(1,6287)=3285, p<2E-16***].
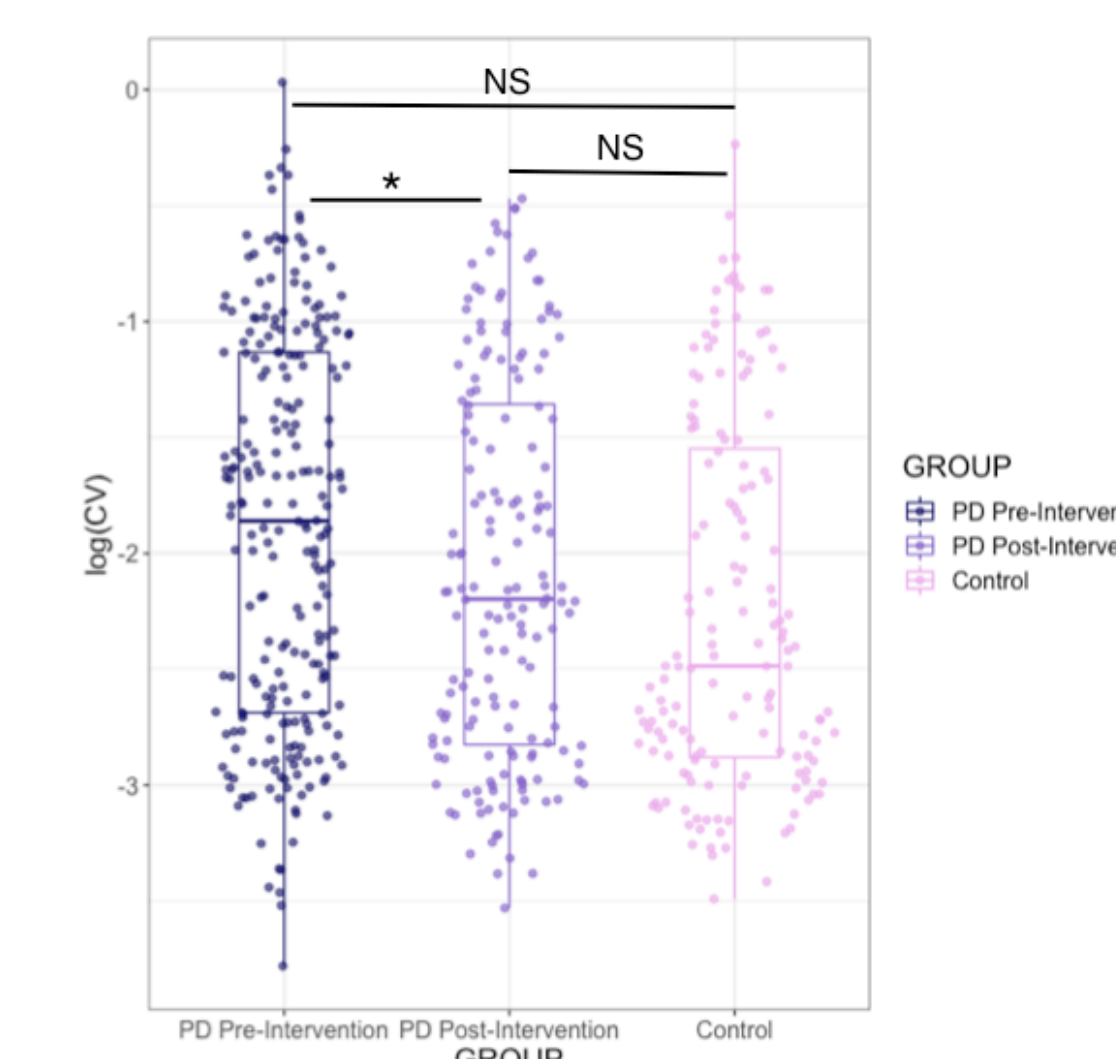

Pre- and post-intervention log(CV) values separated by groove, time of testing, and dance experience. Post-intervention PD CV values were significantly lower than pre-intervention values and were more similar to control CV values (t=2.26, df=366, p=0.0244*).

Pre- and post-intervention PD log(CV) values separated by groove, time of testing, and dance experience. The presence of dance experience predicted significantly lower CV values for both high (diff=-0.15, upr=-0.25, lwr=-0.045, p<0.001***) and low groove (diff=-0.14, upr=-0.24, lwr=-0.038, p<0.001***) songs during initial, but not follow-up, testing.

Associations between UPDRS Improvement, Sensorimotor Coupling, Prior Dance Experience
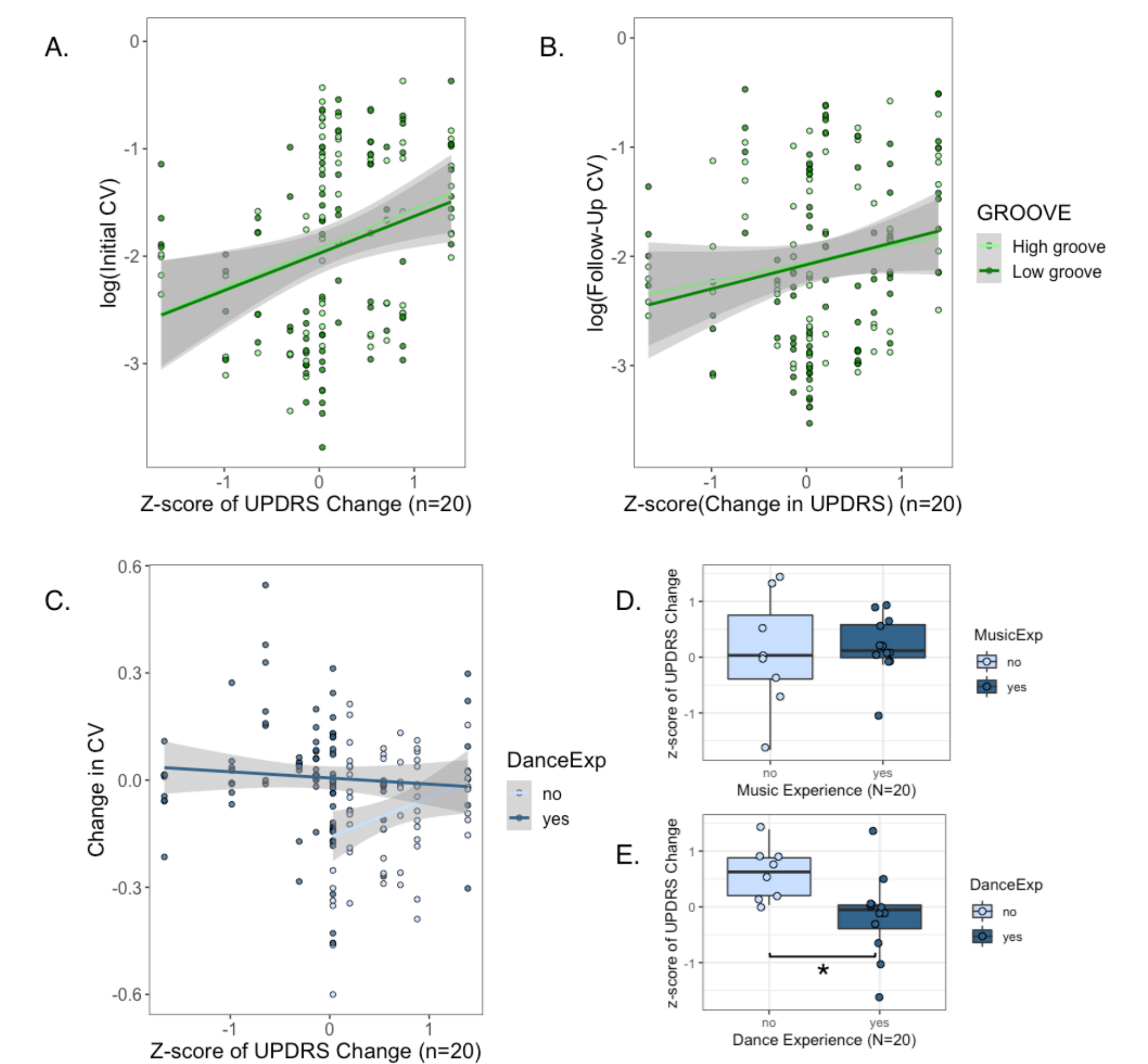
A. Correlation of initial CV and z-scores of changes in UPDRS from baseline to four months by groove. (High Groove: Pearson's correlation: r=0.311, p=0.00492**; Low Groove: r=0.286, p=0.0101*). **B.** Correlation of follow-up CV and z-scores of UPDRS changes from baseline to four months by groove (High Groove: r=0.157, p=0.164; Low Groove: r=0.195, p=0.0823). **C.** Correlation of Change in CV and z-scores of UPDRS change by DE (DE: r=-0.0810, p=0.435; No DE: r=0.277, p=0.0270*). **D, E.** Z-scores of UPDRS changes from baseline to four months (n=20) separated by ME (6D) and DE (6E) (Paired t-tests: ME: t=-0.234, df=9.46, p=0.820; DE: t=2.80, df=17.9, p=0.0119*).

Conclusions

- All but two PD participants exhibited improvement in UPDRS scores post-intervention, supporting previous reports that dance classes improve Pakinsonian symptoms.
- Our results also suggest that music experience is associated with improved beat perception while dance experience is associated with improved tapping performance.
- PD participants with prior dance experience showed enhanced sensorimotor coupling ability during initial testing, yet PD participants who lacked prior dance experience improved post-intervention.
- Enhanced sensorimotor coupling from initial testing was associated with greater improvement in Parkinsonian symptoms. This relationship was not preserved during follow-up testing, likely due to improvements in sensorimotor coupling ability in PD participants without dance experience.
- Previous dance experience was associated with greater improvements in UPDRS scores, suggesting that dance experience was predictive of response to dance classes.

References

Bella, S. D., C. E. Benoit, N. Farrugia, P. E. Keller, H. Obrig, S. Mainka, and S. A. Kotz. "Gait Improvement Via Rhythmic Stimulation in Parkinson's Disease Is Linked to Rhythmic Skills." *Sci Rep* 7 (Feb 24 2017): 42005.

de Natale, E. R., K. S. Paulus, E. Aiello, B. Sanna, A. Manca, G. Sotgiu, P. T. Leali, and F. Deriu. "Dance Therapy Improves Motor and Cognitive Functions in Patients with Parkinson's Disease." *NeuroRehabilitation* 40, no. 1 (2017): 141-44.

Grahn, J. A. "The Role of the Basal Ganglia in Beat Perception: Neuroimaging and Neuropsychological Investigations." *Ann N Y Acad Sci* 1169 (Jul 2009): 35-45.

Hackney, M. E., and G. M. Earhart. "Effects of Dance on Movement Control in Parkinson's Disease: A Comparison of Argentine Tango and American Ballroom." *J Rehabil Med* 41, no. 6 (May 2009): 475-81.

Hulbert, S., A. Ashburn, L. Roberts, and G. Verheyden. "Dance for Parkinson's-the Effects on Whole Body Co-Ordination During Turning Around." *Complement Ther Med* 32 (Jun 2017): 91-97.

Iversen, John R, and Aniruddh D Patel. "The Beat Alignment Test (Bat): Surveying Beat Processing Abilities in the General Population." [In English]. *International Conference on Music Perception and Cognition* 10 (September 2008): 465-68.

Janata, P., S. T. Tomic, and J. M. Haberman. "Sensorimotor Coupling in Music and the Psychology of the Groove." *J Exp Psychol Gen* 141, no. 1 (Feb 2012): 54-75.

Lartillot, O., & Toiviainen, P. (2007). A Matlab toolbox for musical feature extraction from audio. Paper presented at the International Conference on Digital Audio Effects, Bordeaux, France.

Rehfeld, K., A. Luders, A. Hokelmann, V. Lessmann, J. Kaufmann, T. Brigadski, P. Muller, and N. G. Muller. "Dance Training Is Superior to Repetitive Physical Exercise in Inducing Brain Plasticity in the Elderly." *PLoS One* 13, no. 7 (2018): e0196636.

Sharp, K., and J. Hewitt. "Dance as an Intervention for People with Parkinson's Disease: A Systematic Review and Meta-Analysis." *Neurosci Biobehav Rev* 47 (Nov 2014): 445-56.

Acknowledgments