SUPPLEMENTARY MATERIAL FOR 50 SHADES OF GRAY: EFFECT OF THE COLOR SCALE FOR THE ASSESSMENT OF PARKINSON'S DISEASE

P. A. Pérez-Toro[1,2⋆] *, J. C. Vasquez-Correa*[1,2]*, P. Klumpp*[1]*, M. Schuster*[3]*,*
E. Nöth[1], J. R. Orozco-Arroyave[1,2], T. Arias-Vergara[1,2,3]

[1]Pattern Recognition Lab. Friedrich-Alexander Universität, Erlangen-Nürnberg, Erlangen, Germany
[2]Facultad de Ingeniería. Universidad de Antioquia UdeA, Calle 70 No. 52-21, Medellín, Colombia
[3]Department of Otorhinolaryngology, Head and Neck Surgery. Ludwig-Maximilians University, Munich, Germany
⋆corresponding authors: paula.andrea.perez@fau.de

1. DESCRIPTION OF THE SUPPLEMENTATY MATERIAL

This document contains the supplementary material for the paper entitles *"50 Shades of Gray: Effect of the Color Scale for the Assessment of Parkinson's Disease"*. It provides detailed information about the results in the following tables.

Table 1 shows the different reconstruction errors according Mean Squared Error (MSE) for the used color scales and different resolutions.

Table 1: Reconstruction error (MSE) according to the different parameters for the Convolutional AutoEncoders

Color Scales/ Resolutions	3D	15ms	25ms	45ms	**Average**
Original	6.3E-03	5.3E-03	5.8E-03	5.7E-03	5.8E-03
Grayscale	9.1E-03	1.2E-02	8.4E-03	6.2E-03	8.9E-03
RGB-Gray	9.8E-03	1.2E-02	6.5E-03	5.7E-03	8.6E-03
Viridis	5.3E-03	4.3E-03	3.0E-03	4.1E-03	4.2E-03
Jet	8.1E-02	1.0E-01	5.8E-02	4.9E-02	7.3E-02
Average	2.2E-02	2.7E-02	1.6E-02	1.4E-02	2.0E-02

The following tables describe different experiments according to the applied color scales for the spectrograms: (1) Original, (2) Grayscale, (3) Non-linear Gray scale (NL-Gray), (4) Viridis, and (5) Jet. The performance is evaluated according to the Spearman's correlation coefficient (ρ) for the prediction of the standard scales to evaluate movement and speech impairments caused by Parkinson's Disease (PD) such as the third part of the Movement Disorders Society Unified Parkinson's Disease Rating Scale (U-III) [1], the Hoehn & Yahr (H&Y) scale [2], and the modified Frenchay Dysarthria Assessment (mFDA) [3]. The U-III and the H&Y scale aim at describing the neurological state of PD patients, while mFDA aims at evaluating the dysarthria level in diseases that involve speech disorders.. Additionally, we considered the evaluation of several tasks that were described in Section 2 of the paper: (1) T1: Monologue, (2) T2: Read text, (3) T3: DDK, (4) T4: T1 & T2, (5) T5: T1 & T3, (6) T6: T2 & T3, and (7) T7: T1 & T2 & T3.

Table 2 shows the results regarding the severity of the dysarthria level using the raw log-Mel spectrograms in comparison to the standard clinical evaluations. The results of the prediction of the scores using linear grayscale are presented in Table 3. Table 4 shows the Spearman's correlation for the prediction using NL-Gray. The results using the Viridis scale are shown in Table 5. Table 6 shows the results using the Jet scale. Early fusion consists of merging the three different resolutions (15, 25, and 45 ms) and 3D is the 3-channel spectrogram composed by the different resolution and used as input in the Convolutional AutoEncoders (CAE).

Table 2: Spearman's correlation coefficients for the prediction mFDA, U-III, and H&Y score using the raw Mel spectrograms

Task/ Resolutions	3D	15ms	25ms	45ms	Early Fusion
mFDA					
T1	0.36	0.37	0.29	0.32	0.40
T2	0.42	0.47	0.56	0.41	0.55
T3	0.44	0.52	0.53	0.58	0.60
T4	0.42	0.63	0.55	0.58	0.50
T5	**0.56**	**0.66**	**0.63**	0.57	**0.65**
T6	0.47	0.65	0.59	**0.59**	0.63
T7	0.53	0.66	0.62	0.53	0.65
U-III					
T1	0.39	0.21	-0.13	-0.18	0.48
T2	0.20	-0.29	0.34	0.36	0.34
T3	0.42	**0.43**	0.32	0.53	**0.59**
T4	-0.20	0.25	0.34	0.28	0.25
T5	-0.11	0.43	0.31	0.36	0.47
T6	**0.53**	0.41	**0.42**	**0.56**	0.51
T7	0.46	0.39	0.40	0.34	0.40
H&Y					
T1	-0.27	-0.09	-0.16	-0.19	-0.31
T2	0.04	-0.17	-0.03	-0.08	0.00
T3	0.18	0.27	0.25	**0.37**	**0.41**
T4	0.02	0.17	0.13	0.16	-0.12
T5	0.18	0.15	0.14	0.15	0.24
T6	**0.35**	**0.40**	**0.32**	0.36	0.23
T7	0.23	0.12	0.23	0.13	0.18

Table 3: Spearman's correlation coefficients for the prediction mFDA, U-III, and H&Y score using the grayscale Mel spectrograms

Task/ Resolutions	3D	15ms	25ms	45ms	Early Fusion
mFDA					
T1	0.39	0.37	0.32	0.31	0.32
T2	0.38	0.53	0.56	0.43	0.51
T3	**0.62**	0.45	**0.62**	0.48	0.58
T4	0.35	0.50	0.49	**0.59**	0.59
T5	0.57	0.58	0.58	0.57	0.57
T6	0.60	0.59	0.56	0.52	0.61
T7	0.60	**0.69**	0.59	0.57	**0.62**
U-III					
T1	0.15	0.44	0.38	0.20	0.25
T2	0.29	0.16	**0.52**	0.15	0.35
T3	**0.40**	0.37	0.29	**0.55**	0.49
T4	0.20	0.32	0.34	0.33	0.28
T5	0.30	0.41	0.30	0.33	0.36
T6	0.32	**0.58**	0.50	0.47	**0.53**
T7	0.30	0.45	0.45	0.23	0.30
H&Y					
T1	-0.13	0.28	0.03	0.01	0.10
T2	0.12	0.04	0.21	0.10	0.20
T3	**0.39**	0.23	0.18	0.21	0.27
T4	-0.35	0.13	0.09	0.19	-0.18
T5	0.17	0.28	0.24	0.29	0.26
T6	0.37	**0.41**	0.38	0.28	**0.35**
T7	0.23	0.37	**0.45**	**0.33**	0.20

Table 4: Spearman's correlation coefficients for the prediction mFDA, U-III, and H&Y score using the NL-Gray Mel spectrograms

Task/ Resolutions	3D	15ms	25ms	45ms	Early Fusion
mFDA					
T1	0.44	0.47	0.38	0.44	0.33
T2	**0.63**	0.51	0.37	0.34	0.53
T3	0.54	0.48	0.47	0.60	0.62
T4	0.55	0.64	0.46	0.46	0.57
T5	0.47	0.60	0.54	**0.65**	**0.64**
T6	0.57	0.63	0.55	0.61	0.59
T7	0.62	**0.71**	**0.57**	0.60	0.64
U-III					
T1	0.00	0.14	-0.20	0.34	0.00
T2	0.16	-0.28	-0.30	-0.18	-0.27
T3	**0.39**	**0.59**	0.36	**0.52**	**0.65**
T4	0.15	-0.10	-0.26	0.40	0.26
T5	0.24	0.46	**0.45**	0.45	0.38
T6	0.33	0.48	0.39	0.46	0.51
T7	0.22	0.40	0.31	0.47	0.34
H&Y					
T1	-0.11	-0.22	-0.06	-0.31	-0.19
T2	0.01	-0.24	0.03	0.21	0.02
T3	**0.35**	**0.50**	0.18	0.32	**0.34**
T4	-0.34	-0.16	-0.12	-0.30	-0.13
T5	0.17	0.18	0.17	0.17	0.26
T6	0.32	0.24	**0.25**	**0.40**	0.29
T7	0.22	0.24	0.21	0.05	0.16

Table 5: Spearman's correlation coefficients for the prediction mFDA, U-III, and H&Y score using the Viridis Mel spectrograms

Task/ Resolutions	3D	15ms	25ms	45ms	Early Fusion
mFDA					
T1	0.38	0.37	0.35	0.40	0.45
T2	0.37	0.44	0.40	0.60	0.59
T3	0.43	0.53	0.49	0.43	0.52
T4	0.57	0.51	0.52	0.52	0.56
T5	0.57	**0.61**	0.57	0.56	**0.65**
T6	0.46	0.57	**0.58**	0.61	0.64
T7	**0.58**	0.59	0.54	**0.63**	0.64
U-III					
T1	-0.21	0.30	-0.21	-0.24	0.12
T2	0.32	0.52	0.32	-0.13	0.34
T3	0.45	0.53	**0.58**	0.23	0.50
T4	0.20	0.53	0.44	0.14	0.26
T5	0.36	0.44	0.56	-0.25	**0.52**
T6	**0.46**	**0.60**	0.58	**0.34**	0.47
T7	0.37	0.42	0.55	-0.21	0.46
H&Y					
T1	-0.36	-0.10	-0.29	-0.29	-0.15
T2	-0.35	-0.06	0.03	-0.07	-0.03
T3	0.21	**0.22**	**0.42**	0.20	**0.34**
T4	-0.23	-0.08	-0.07	-0.19	-0.21
T5	**0.24**	0.14	0.16	0.11	0.26
T6	0.05	0.20	0.18	**0.37**	0.26
T7	-0.10	-0.04	0.18	0.05	0.14

Table 6: Spearman's correlation coefficients for the prediction mFDA, U-III, and H&Y score using the Jet Mel spectrograms

Task/ Resolutions	3D	15ms	25ms	45ms	Early Fusion
mFDA					
T1	0.49	0.31	0.46	0.46	0.45
T2	0.34	0.55	0.38	0.55	0.51
T3	0.42	0.42	0.47	0.32	0.48
T4	0.56	**0.69**	0.44	0.59	0.62
T5	**0.57**	0.56	0.57	0.57	**0.65**
T6	0.53	0.56	0.56	0.59	0.61
T7	0.57	0.60	**0.59**	**0.65**	0.64
U-III					
T1	0.24	-0.13	0.22	-0.20	0.00
T2	0.11	0.24	-0.30	0.32	0.22
T3	**0.63**	**0.55**	0.52	**0.38**	**0.50**
T4	-0.11	-0.20	-0.20	0.36	0.01
T5	0.44	0.46	**0.53**	0.33	0.41
T6	0.47	0.39	0.35	0.38	0.47
T7	-0.14	0.38	0.47	0.35	0.34
H&Y					
T1	-0.20	-0.24	-0.25	-0.22	-0.18
T2	-0.18	-0.10	-0.11	-0.33	-0.23
T3	**0.41**	**0.39**	**0.30**	**0.39**	**0.41**
T4	-0.28	-0.25	-0.39	-0.25	-0.29
T5	0.16	0.24	0.29	0.13	0.28
T6	0.28	0.17	0.30	0.19	0.25
T7	0.21	0.26	0.25	-0.11	0.05

2. REFERENCES

[1] C. G. Goetz, B. C. Tilley, S. R. Shaftman, G. T. Stebbins, S. Fahn, P. Martinez-Martin, W. Poewe, C. Sampaio, et al., "Movement Disorder Society-sponsored revision of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS): Scale presentation and clinimetric testing results," *Movement Disorders*, vol. 23, no. 15, pp. 2129–2170, 2008.

[2] R. Bhidayasiri and D. Tarsy, "Parkinson's disease: Hoehn and Yahr scale," in *Movement Disorders: A Video Atlas*, pp. 4–5. Springer, 2012.

[3] J. C. Vásquez-Correa, J. R. Orozco-Arroyave, T. Bocklet, and E. Nöth, "Towards an automatic evaluation of the dysarthria level of patients with Parkinson's disease," *Journal of Communication Disorders*, vol. 76, pp. 21–36, 2018.