Supplementary Materials

Table S1: MIN2Net architecture, where C is the number of channels, T is the number of time points, z is the size of latent vector and N is the number of classes. Noted that the data format of Conv2D is "channels last"

Blocks		Layer	Filter	Size	Stride	Activation	Options	Output
Autoencoder	Encoder	Input		$(1,T,C)$				$(1,T,C)$
		Conv2D	C	(1,64)	1	ELU	padding=same	$(1,T,C)$
		BatchNormalization						$(1,T,C)$
		AveragePooling2D		$(1,\ T//100)$				$(1,100,C)$
		Conv2D	10	(1,32)	1	ELU	padding=same	(1,100,10)
		BatchNormalization						(1,100,10)
		AveragePooling2D		(1,4)				(1,25,10)
		Flatten						(250)
	Latent	FC		(z)				(z)
	Decoder	FC		(250)				(250)
		Reshape		(1, 25, 10)				(1, 25, 10)
		Conv2DTranspose	10	(1,64)	4	ELU	padding=same	(1, 100, 10)
		Conv2DTranspose	C	(1,32)	$T//100$	ELU	padding=same	$(1,T,C)$
Metric learning		Latent						(z)
Supervised Learning		Latent						(z)
		FC	N			softmax		(N)

z is equal to C and 64 for 2- and 3-class classification, respectively.

Since the latent vector (z) of MIN2Net plays a substantial role in preserving the meaningful features from high-dimensional EEG signals, we experiment to find the optimal size of the MIN2Net's latent vector. Table S2 presents the two- and three-class classification results when different sizes of the latent vector (z) are contributed in MIN2Net. It can be seen that when marking the size of latent vector as C (where C is the number of channels), the MIN2Net gained the optimal performance in the binary subject-independent classification for all used datasets. For the binary subject-dependent classification, the latent vector size of 8 produced the best performance of MIN2Net on the BCIC IV 2a dataset. Additionally, the optimal performance of MIN2Net on the three-class subject-independent for the OpenBMI dataset was obtained by selecting a 64 latent vector size. As a result of this finding, setting the size of the latent vector to C could aid MIN2Net in preserving meaningful features from EEG-MI signals and could even be used as a starting point for evaluating new MI datasets.

Table S2: Classification performance (Accuracy $\pm$ SD and F1-score $\pm$ SD) in % of MIN2Net using the subject-dependent and subject-independent manners comparisons on four different sizes of latent vector (z). Bold denotes the best numerical values.

Dataset	**Task**	*# latent vector*	**Subject-dependent**		**Subject-independent**	
			Accuracy	**F1-score**	**Accuracy**	**F1-score**
BCIC IV 2a	two-class	8	**66.47 $\pm$ 16.31**	**65.67 $\pm$ 18.38**	59.01 $\pm$ 8.30	43.84 $\pm$ 21.86
		20 (C)	65.23 $\pm$ 16.14	64.72 $\pm$ 18.39	**60.03 $\pm$ 9.24**	49.09 $\pm$ 23.28
		64	63.18 $\pm$ 16.01	61.25 $\pm$ 18.56	60.00 $\pm$ 8.34	**50.94 $\pm$ 18.84**
		256	62.16 $\pm$ 15.04	60.67 $\pm$ 17.35	59.46 $\pm$ 8.40	51.80 $\pm$ 17.73
SMR-BCI	two-class	8	63.95 $\pm$ 15.59	61.63 $\pm$ 16.88	54.21 $\pm$ 11.82	49.79 $\pm$ 21.90
		15 (C)	**65.90 $\pm$ 16.50**	**64.13 $\pm$ 17.66**	**59.79 $\pm$ 13.72**	**61.10 $\pm$ 23.64**
		64	61.36 $\pm$ 14.09	59.27 $\pm$ 16.28	57.43 $\pm$ 12.46	50.31 $\pm$ 28.41
		256	63.14 $\pm$ 13.69	59.38 $\pm$ 17.00	57.98 $\pm$ 11.60	53.75 $\pm$ 25.55
OpenBMI	two-class	8	60.39 $\pm$ 14.54	62.03 $\pm$ 15.53	70.94 $\pm$ 13.70	71.29 $\pm$ 13.75
		20 (C)	**61.03 $\pm$ 14.47**	**63.59 $\pm$ 14.52**	**72.03 $\pm$ 14.04**	**72.62 $\pm$ 14.14**
		64	59.13 $\pm$ 13.18	61.36 $\pm$ 13.80	70.66 $\pm$ 13.66	70.24 $\pm$ 14.43
		256	58.18 $\pm$ 12.58	59.97 $\pm$ 13.45	70.58 $\pm$ 13.62	70.08 $\pm$ 14.71
OpenBMI	three-class	8	-	-	61.83$\pm$9.05	59.11$\pm$9.82
		20 (C)	-	-	64.89$\pm$10.77	62.93$\pm$11.68
		64	-	-	**68.97$\pm$11.84**	**68.07$\pm$12.34**
		256	-	-	68.81$\pm$12.25	68.04$\pm$12.70

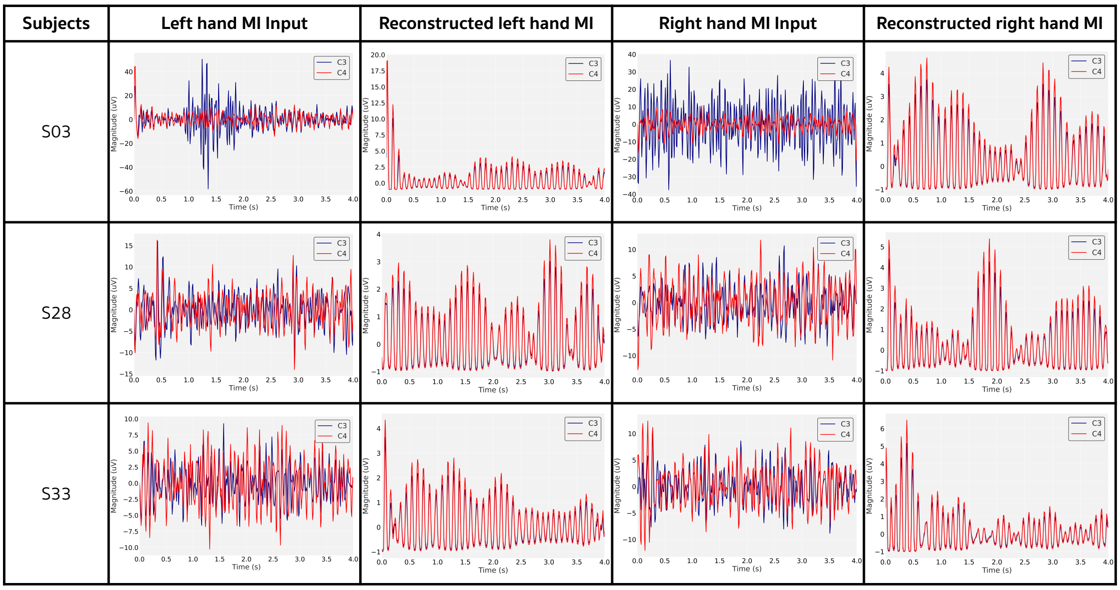

Fig. S1: Visualization of a time series of a single-trial EEG of the OpenBMI dataset on both the input and reconstructed EEG-MI signals in certain channels ($C3$ and $C4$) using the proposed method. The plot illustrated how the reconstructed signals from different classes interact in different patterns.

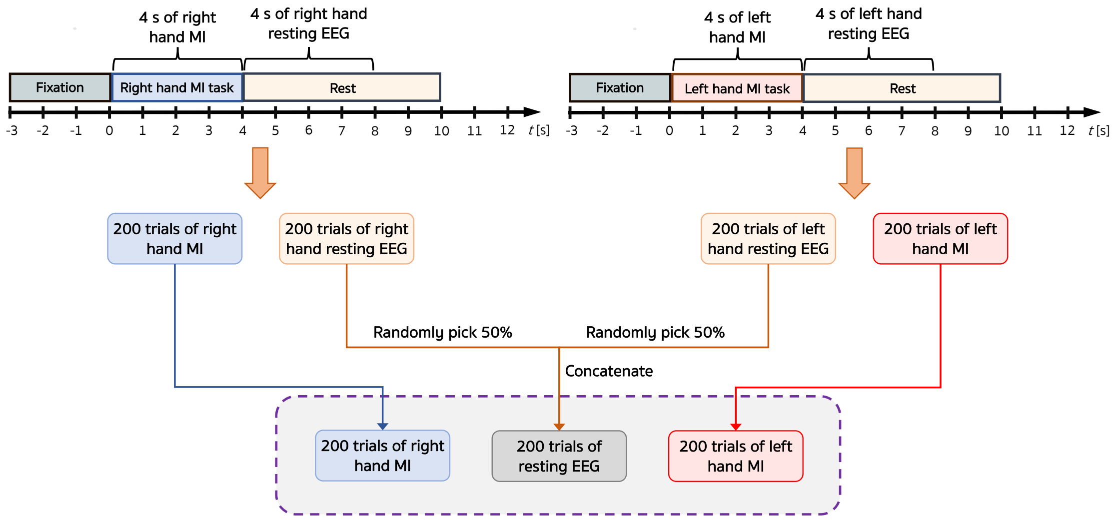

Fig. S2: An experimental procedure demonstrates how the OpenBMI dataset was used to segment a subject's EEG signal into three classes.

Table S3: Classification accuracy and F1-score (in %, ± SD) on the subject-dependent manner for the two-class classification of MI. Bold denotes the best numerical values.

β_1	β_2	β_3	BCIC IV 2a		SMR BCI		OpenBMI	
			Accuracy	F1-score	Accuracy	F1-score	Accuracy	F1-score
0.1	0.1	0.1	63.23 ± 12.63	63.17 ± 13.64	63.83 ± 15.74	60.04 ± 18.21	60.71 ± 13.89	63.16 ± 13.97
0.1	0.1	0.5	63.04 ± 14.94	62.93 ± 16.32	**66.10 ± 15.25**	63.23 ± 17.48	61.16 ± 15.27	63.57 ± 15.43
0.1	0.1	1.0	63.40 ± 15.65	63.45 ± 16.51	65.90 ± 16.50	**64.13 ± 17.66**	60.53 ± 15.65	62.91 ± 16.04
0.1	0.5	0.1	59.60 ± 11.79	58.75 ± 13.16	60.95 ± 16.19	57.25 ± 18.44	60.24 ± 14.05	63.13 ± 13.82
0.1	0.5	0.5	**64.54 ± 14.65**	63.97 ± 15.92	65.45 ± 16.41	61.32 ± 19.40	60.96 ± 14.33	63.36 ± 14.70
0.1	0.5	1.0	63.67 ± 14.80	63.42 ± 16.22	65.79 ± 15.75	62.74 ± 17.82	60.71 ± 14.94	63.38 ± 15.06
0.1	1.0	0.1	57.69 ± 11.57	55.90 ± 13.85	60.12 ± 16.01	58.03 ± 17.68	58.21 ± 13.10	61.18 ± 13.36
0.1	1.0	0.5	61.36 ± 13.16	60.24 ± 14.95	63.38 ± 18.19	60.30 ± 20.28	60.63 ± 14.55	62.98 ± 14.83
0.1	1.0	1.0	63.18 ± 14.13	62.20 ± 16.14	65.81 ± 16.70	61.88 ± 19.37	60.93 ± 14.66	63.37 ± 14.99
0.5	0.1	0.1	59.34 ± 10.01	59.29 ± 10.81	63.31 ± 15.08	59.94 ± 17.31	58.98 ± 13.06	60.73 ± 13.75
0.5	0.1	0.5	62.81 ± 13.99	63.40 ± 15.06	65.38 ± 15.46	61.25 ± 18.31	61.12 ± 14.43	63.38 ± 14.61
0.5	0.1	1.0	63.50 ± 14.78	63.64 ± 16.23	64.67 ± 16.46	61.81 ± 18.83	**61.22 ± 15.03**	63.46 ± 15.13
0.5	0.5	0.1	58.35 ± 10.56	57.67 ± 11.76	60.55 ± 15.66	57.52 ± 18.21	57.68 ± 12.66	59.85 ± 13.25
0.5	0.5	0.5	62.61 ± 12.99	62.59 ± 14.23	63.71 ± 15.92	59.56 ± 18.61	60.49 ± 13.72	62.98 ± 13.76
0.5	0.5	1.0	63.77 ± 13.99	63.62 ± 15.00	64.17 ± 16.00	60.29 ± 18.71	61.03 ± 14.47	**63.59 ± 14.53**
0.5	1.0	0.1	58.44 ± 10.07	57.32 ± 11.77	56.00 ± 14.11	51.71 ± 17.99	56.35 ± 11.78	58.50 ± 12.64
0.5	1.0	0.5	63.06 ± 12.96	61.82 ± 14.44	58.76 ± 13.79	54.93 ± 17.46	58.68 ± 13.41	60.98 ± 14.07
0.5	1.0	1.0	63.87 ± 13.84	63.11 ± 15.31	60.14 ± 14.78	55.52 ± 18.25	59.28 ± 13.70	61.75 ± 14.18
1.0	0.1	0.1	56.81 ± 8.08	56.93 ± 10.62	59.98 ± 13.81	55.51 ± 17.97	56.69 ± 12.27	58.15 ± 13.16
1.0	0.1	0.5	62.21 ± 12.72	63.10 ± 14.23	62.81 ± 14.46	58.12 ± 18.76	60.31 ± 13.73	62.50 ± 14.16
1.0	0.1	1.0	63.46 ± 14.33	**64.28 ± 15.27**	63.12 ± 15.11	59.10 ± 18.69	60.61 ± 14.28	63.13 ± 14.44
1.0	0.5	0.1	58.40 ± 10.01	57.88 ± 11.19	56.05 ± 13.92	51.75 ± 17.79	56.36 ± 12.07	58.29 ± 13.34
1.0	0.5	0.5	61.23 ± 10.96	60.86 ± 12.10	61.02 ± 13.69	56.11 ± 17.90	59.40 ± 13.29	61.31 ± 14.06
1.0	0.5	1.0	63.94 ± 13.39	64.14 ± 13.99	61.83 ± 13.99	56.93 ± 18.19	60.18 ± 13.74	62.41 ± 14.29
1.0	1.0	0.1	58.30 ± 10.27	57.63 ± 11.31	55.98 ± 13.62	51.69 ± 17.68	56.16 ± 11.50	58.02 ± 12.89
1.0	1.0	0.5	61.88 ± 11.36	60.51 ± 12.91	60.00 ± 13.62	54.71 ± 18.50	58.36 ± 13.10	60.38 ± 13.95
1.0	1.0	1.0	62.39 ± 12.62	61.94 ± 13.71	61.19 ± 13.13	55.91 ± 17.62	59.78 ± 13.73	61.90 ± 14.33

Table S4: Classification accuracy and F1-score (in %, ± SD) on the subject-independent manner for the two-class classification of MI. Bold denotes the best numerical values.

β_1	β_2	β_3	BCIC IV 2a		SMR BCI		OpenBMI	
			Accuracy	**F1-score**	**Accuracy**	**F1-score**	**Accuracy**	**F1-score**
0.1	0.1	0.1	58.81 ± 8.76	43.39 ± 23.51	58.07 ± 11.86	56.10 ± 24.06	71.59 ± 13.94	71.95 ± 14.75
0.1	0.1	0.5	59.17 ± 8.34	50.28 ± 18.35	57.64 ± 12.80	58.07 ± 23.21	71.45 ± 14.24	71.97 ± 14.40
0.1	0.1	1.0	57.62 ± 8.16	46.87 ± 20.60	58.71 ± 12.18	60.82 ± 20.14	71.40 ± 14.35	71.94 ± 14.51
0.1	0.5	0.1	55.09 ± 7.35	38.30 ± 24.19	57.76 ± 11.80	57.09 ± 24.45	69.79 ± 14.49	69.36 ± 15.74
0.1	0.5	0.5	58.02 ± 9.05	45.10 ± 22.86	60.00 ± 13.04	60.58 ± 22.04	70.02 ± 14.53	69.40 ± 16.45
0.1	0.5	1.0	57.78 ± 8.31	44.05 ± 22.07	58.71 ± 12.52	60.72 ± 20.57	71.13 ± 13.97	71.51 ± 14.13
0.1	1.0	0.1	52.89 ± 7.87	**54.16 ± 18.23**	59.79 ± 13.72	**61.10 ± 23.64**	69.54 ± 14.28	68.83 ± 15.80
0.1	1.0	0.5	53.49 ± 7.05	40.93 ± 26.35	58.07 ± 11.36	58.40 ± 21.67	69.86 ± 14.22	69.32 ± 15.74
0.1	1.0	1.0	53.87 ± 7.38	36.79 ± 23.55	59.50 ± 13.03	60.57 ± 22.31	69.95 ± 14.58	69.35 ± 16.39
0.5	0.1	0.1	57.89 ± 8.42	37.33 ± 25.69	59.38 ± 12.87	56.70 ± 26.25	62.43 ± 14.61	61.88 ± 15.24
0.5	0.1	0.5	59.10 ± 8.64	43.27 ± 23.35	59.10 ± 13.50	58.32 ± 24.60	71.85 ± 14.18	71.35 ± 15.98
0.5	0.1	1.0	**60.03 ± 9.24**	49.09 ± 23.28	58.52 ± 12.91	58.82 ± 22.89	71.83 ± 13.95	71.25 ± 15.35
0.5	0.5	0.1	57.65 ± 8.08	37.54 ± 25.74	57.90 ± 11.16	56.79 ± 23.30	70.89 ± 14.13	71.46 ± 14.09
0.5	0.5	0.5	58.21 ± 8.87	42.65 ± 23.81	58.86 ± 12.58	56.13 ± 25.06	71.30 ± 14.04	72.15 ± 13.76
0.5	0.5	1.0	59.14 ± 8.79	47.03 ± 21.61	58.81 ± 14.01	58.18 ± 23.42	72.03 ± 14.04	**72.62 ± 14.14**
0.5	1.0	0.1	57.69 ± 7.54	39.64 ± 23.36	58.21 ± 11.86	57.68 ± 22.22	70.47 ± 13.59	71.07 ± 13.80
0.5	1.0	0.5	58.02 ± 7.53	41.43 ± 23.78	58.88 ± 11.74	57.75 ± 23.18	70.45 ± 13.87	70.77 ± 14.28
0.5	1.0	1.0	58.40 ± 8.52	45.02 ± 21.63	59.60 ± 12.63	58.46 ± 22.85	70.83 ± 13.63	70.99 ± 13.97
1.0	0.1	0.1	55.91 ± 6.70	34.63 ± 24.83	57.26 ± 10.06	54.40 ± 23.60	54.52 ± 11.08	54.17 ± 11.57
1.0	0.1	0.5	58.18 ± 8.70	40.77 ± 25.77	58.00 ± 11.06	56.38 ± 24.07	71.12 ± 14.55	71.42 ± 15.02
1.0	0.1	1.0	59.20 ± 8.20	45.32 ± 23.50	58.50 ± 11.28	57.52 ± 23.90	**72.20 ± 14.19**	72.40 ± 14.70
1.0	0.5	0.1	58.27 ± 8.64	38.16 ± 26.01	58.05 ± 11.31	57.61 ± 21.90	70.50 ± 13.92	71.27 ± 14.26
1.0	0.5	0.5	58.84 ± 8.61	42.66 ± 23.50	60.12 ± 12.22	58.41 ± 23.23	70.66 ± 13.80	70.98 ± 14.41
1.0	0.5	1.0	59.10 ± 9.39	43.13 ± 25.48	59.40 ± 11.67	58.41 ± 23.11	71.19 ± 13.67	71.50 ± 14.07
1.0	1.0	0.1	58.26 ± 8.64	38.33 ± 25.80	57.74 ± 10.48	57.56 ± 21.05	70.26 ± 13.59	71.05 ± 13.60
1.0	1.0	0.5	57.95 ± 7.76	38.65 ± 24.68	59.14 ± 11.34	58.22 ± 22.10	70.56 ± 13.33	70.86 ± 13.60
1.0	1.0	1.0	58.55 ± 8.99	43.96 ± 22.80	**60.69 ± 13.04**	58.25 ± 25.13	70.86 ± 13.66	71.14 ± 14.03