NEURAL NETWORK RESULTS

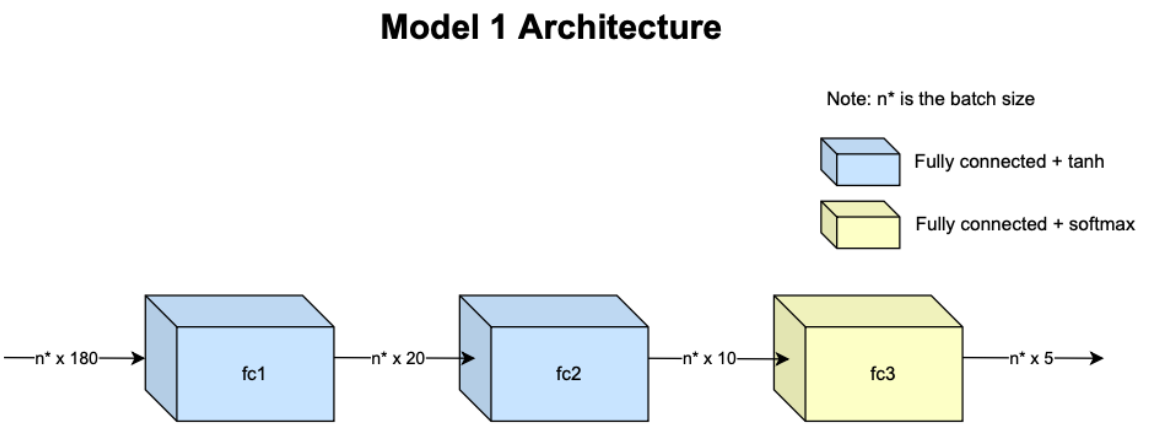
Notes:

- When predicting properties, the order of the labels for the confusion matrix are
  1. Smoothness
  2. Thickness
  3. Warmth
  4. Flexibility
  5. Softness
- When predicting properties, the macro F1 score was used as the data was balanced (same number of observations for each property)

(1) Estimating the PROPERTY based on available data:

- Chance classification accuracy: 20% (1/5)
- Used Leave One Participant Out CV

MODEL 1: MODEL WITH 3 LINEAR FEATURES (USED ALL 180 FEATURES AS INPUT)



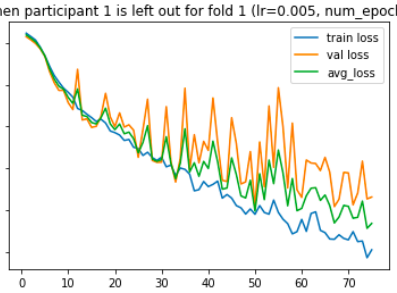
MODEL 1a: lr = 0.005, num epochs = 75

Confusion matrix	Average Micro F1 score	Average Macro F1 score	Overall accuracy
[[100 53 31 56 12] [42 80 32 59 39] [64 60 40 57 31] [35 32 14 138 33] [43 52 26 82 49]]	0.32	0.26	32.3%

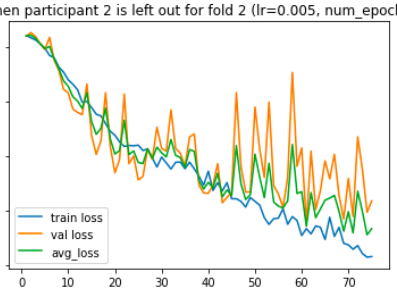
Participant left out	Confusion matrix	Micro F1 score	Macro F1 score	Classification accuracy
1	[[15 3 0 0 0] [8 9 1 0 0] [17 1 0 0 0] [4 12 2 0 0] [4 14 0 0 0]]	0.27	0.15	26.67%
2	[[1 0 0 17 0] [0 6 0 12 0] [0 18 0 0 0] [0 0 0 18 0] [0 1 0 17 0]]	0.28	0.16	27.78%
3	[[11 0 1 6 0] [4 1 8 5 0] [2 0 3 13 0] [1 0 0 17 0] [3 2 7 6 0]]	0.36	0.27	35.56%
4	[[5 0 13 0 0] [0 9 4 1 4] [1 5 6 1 5] [0 2 0 13 3] [0 1 6 3 8]]	0.46	0.47	45.56%
5	[[8 0 7 0 3] [0 1 0 0 17] [5 0 8 0 5] [0 0 0 9 9] [0 0 0 0 18]]	0.49	0.46	48.89%
6	[[6 2 0 6 4] [0 7 0 5 6] [0 7 1 3 7] [1 0 0 14 3] [1 1 0 13 3]]	0.34	0.32	34.44%
7	[[5 13 0 0 0] [0 12 0 0 6] [2 11 0 0 5] [0 10 0 0 8] [0 5 0 0 13]]	0.33	0.25	33.33%
8	[[4 1 4 8 1] [1 1 9 5 2] [8 2 4 2 2] [2 0 5 10 1] [1 0 3 9 5]]	0.27	0.25	26.67%

19	[[3 10 5 0 0] [0 8 4 6 0] [0 5 8 5 0] [0 1 0 15 2] [0 11 1 6 0]]	0.38	0.33	37.78%
21	[[18 0 0 0 0] [18 0 0 0 0] [18 0 0 0 0] [18 0 0 0 0] [18 0 0 0 0]]	0.2	0.07	20.00%
22	[[8 4 1 1 4] [5 4 3 3 3] [3 1 5 3 6] [2 1 2 6 7] [3 3 4 6 2]]	0.28	0.28	27.78%
23	[[0 14 0 4 0] [0 5 0 12 1] [5 3 0 10 0] [0 2 0 16 0] [1 8 0 9 0]]	0.23	0.13	23.33%
24	[[14 4 0 0 0] [6 9 3 0 0] [3 7 5 2 1] [7 3 5 3 0] [11 2 5 0 0]]	0.34	0.29	34.44%
25	[[2 2 0 14 0] [0 8 0 10 0] [0 0 0 18 0] [0 1 0 17 0] [1 4 0 13 0]]	0.3	0.21	30.0%

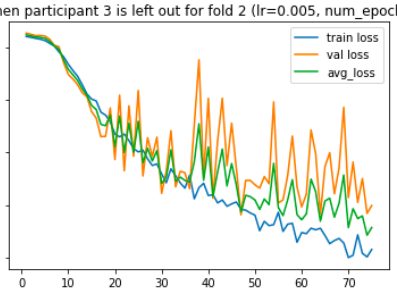
Loss when participant 1 is left out for fold 1 (lr=0.005, num_epochs =75)



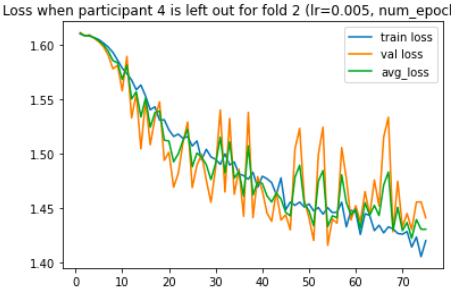
Loss when participant 2 is left out for fold 2 (lr=0.005, num_epochs =75)



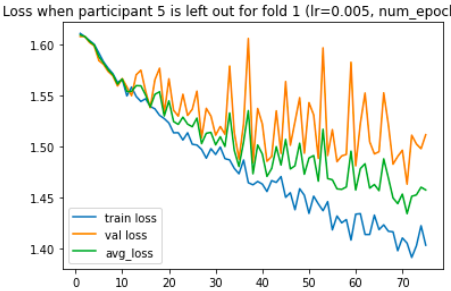
Loss when participant 3 is left out for fold 2 (lr=0.005, num_epochs =75)



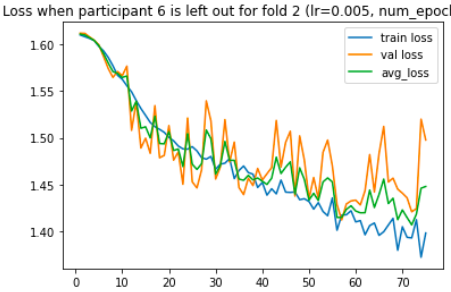
Loss when participant 4 is left out for fold 2 (lr=0.005, num_epochs =75)



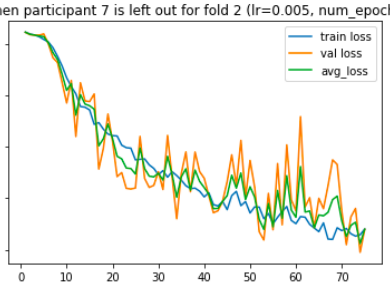
Loss when participant 5 is left out for fold 1 (lr=0.005, num_epochs =75)



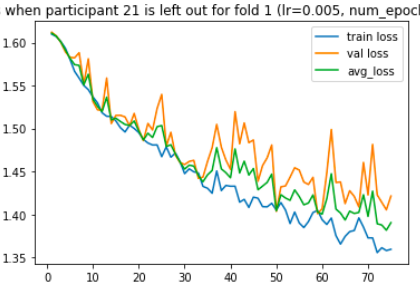
Loss when participant 6 is left out for fold 2 (lr=0.005, num_epochs =75)



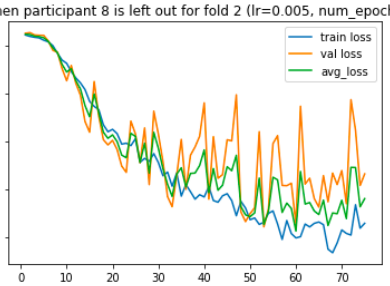
Loss when participant 7 is left out for fold 2 (lr=0.005, num_epochs =75)



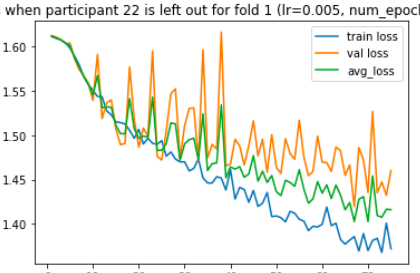
Loss when participant 21 is left out for fold 1 (lr=0.005, num_epochs =75)



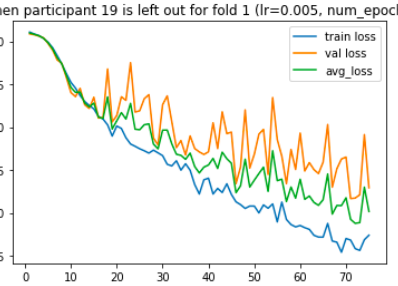
Loss when participant 8 is left out for fold 2 (lr=0.005, num_epochs =75)



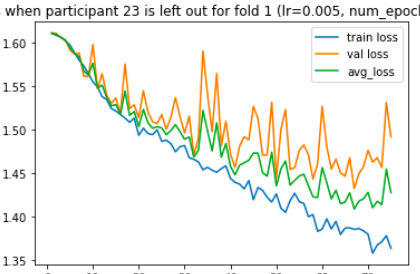
Loss when participant 22 is left out for fold 1 (lr=0.005, num_epochs =75)



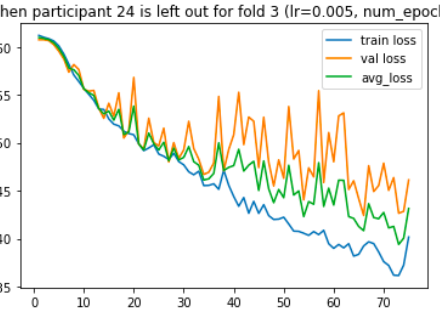
Loss when participant 19 is left out for fold 1 (lr=0.005, num_epochs =75)



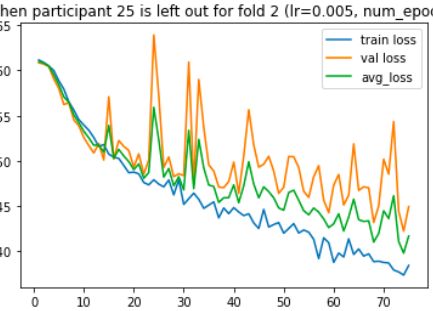
Loss when participant 23 is left out for fold 1 (lr=0.005, num_epochs =75)



Loss when participant 24 is left out for fold 3 (lr=0.005, num_epochs =75)



Loss when participant 25 is left out for fold 2 (lr=0.005, num_epochs =75)



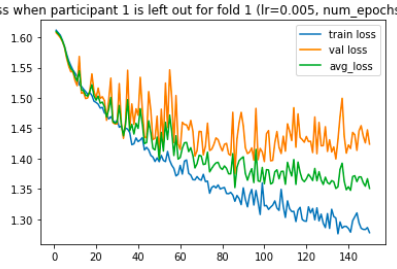
MODEL 1b: lr = 0.005, num epochs = 150

Confusion matrix	Average Micro F1 score	Average Macro F1 score	Overall accuracy
[[113 48 35 38 18] [51 88 25 49 39] [69 56 45 53 29] [45 34 22 120 31] [50 44 42 65 51]]	0.33	0.26	33.1%

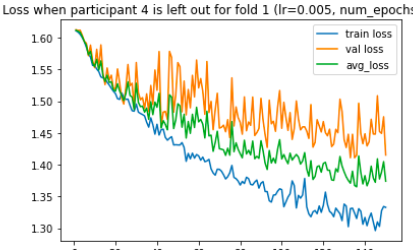
Participant left out	Confusion matrix	Micro F1 score	Macro F1 score	Classification accuracy
1	[[15 0 3 0 0] [13 5 0 0 0] [17 0 1 0 0] [7 8 2 1 0] [4 7 6 1 0]]	0.24	0.17	24.44%
2	[[0 7 4 4 3] [0 14 0 0 4] [0 18 0 0 0] [0 0 1 16 1] [0 10 0 6 2]]	0.36	0.26	35.56%
3	[[16 0 1 1 0] [2 5 3 8 0] [2 3 2 11 0] [0 0 0 18 0] [4 1 5 8 0]]	0.46	0.37	45.56%
4	[[7 0 11 0 0] [1 7 4 1 5] [5 1 7 2 3] [0 1 1 9 7] [1 0 5 2 10]]	0.44	0.46	44.44%
5	[[12 4 1 0 1] [0 10 0 0 8] [6 5 2 0 5] [0 1 0 8 9] [0 0 0 0 18]]	0.56	0.52	55.56%
6	[[0 7 3 6 2] [0 10 0 5 3] [0 12 1 1 4] [0 2 0 13 3] [0 1 2 12 3]]	0.3	0.23	30.0%

7	[[0 9 9 0 0] [0 8 10 0 0] [0 1 17 0 0] [0 8 7 0 3] [0 3 13 0 2]]	0.3	0.19	30.0%
8	[[4 0 1 13 0] [2 1 1 12 2] [9 1 3 4 1] [2 1 2 13 0] [0 0 1 16 1]]	0.24	0.2	24.44%
19	[[0 6 0 1 11] [0 0 0 5 13] [0 0 0 6 12] [0 0 0 14 4] [0 5 0 2 11]]	0.28	0.19	27.78%
21	[[18 0 0 0 0] [17 0 0 1 0] [18 0 0 0 0] [18 0 0 0 0] [18 0 0 0 0]]	0.2	0.07	20.0%
22	[[7 9 1 0 1] [1 14 1 0 2] [0 10 4 1 3] [1 8 4 1 4] [2 10 3 0 3]]	0.32	0.29	32.22%
23	[[14 2 0 2 0] [5 2 1 8 2] [6 1 0 10 1] [4 0 2 12 0] [8 1 1 7 1]]	0.32	0.24	32.22%
24	[[14 3 1 0 0] [7 6 5 0 0] [5 4 8 1 0] [13 2 3 0 0] [11 1 6 0 0]]	0.31	0.23	31.11%
25	[[6 1 0 11 0] [3 6 0 9 0] [1 0 0 17 0] [0 3 0 15 0] [2 5 0 11 0]]	0.3	0.23	30.0%

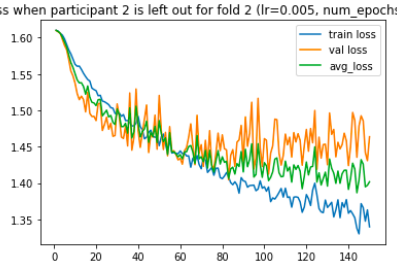
Loss when participant 1 is left out for fold 1 (lr=0.005, num_epochs =150)



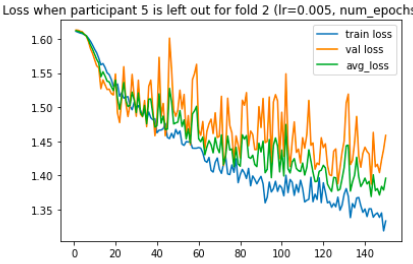
Loss when participant 4 is left out for fold 1 (lr=0.005, num_epochs =150)



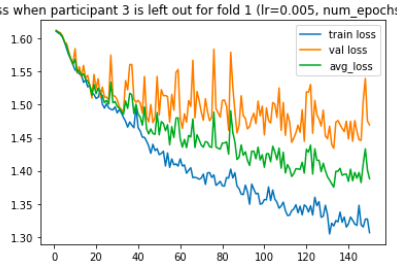
Loss when participant 2 is left out for fold 2 (lr=0.005, num_epochs =150)



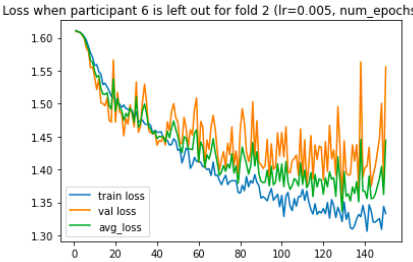
Loss when participant 5 is left out for fold 2 (lr=0.005, num_epochs =150)



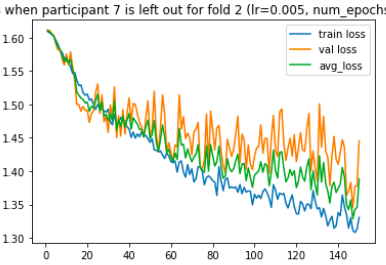
Loss when participant 3 is left out for fold 1 (lr=0.005, num_epochs =150)



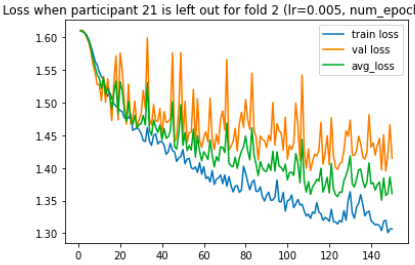
Loss when participant 6 is left out for fold 2 (lr=0.005, num_epochs =150)



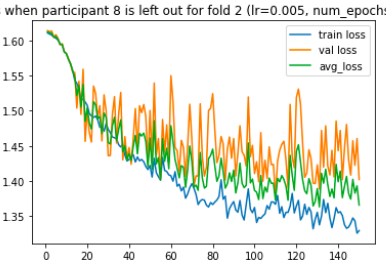
Loss when participant 7 is left out for fold 2 (lr=0.005, num_epochs =150)



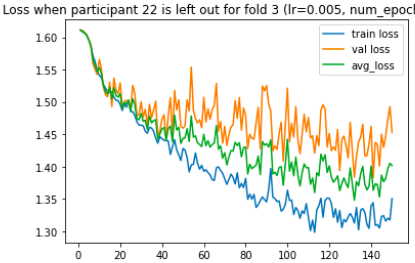
Loss when participant 21 is left out for fold 2 (lr=0.005, num_epochs =150)



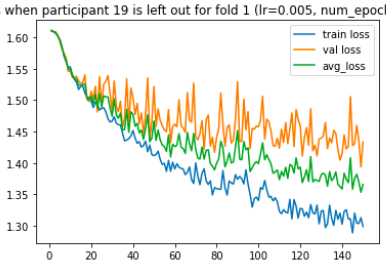
Loss when participant 8 is left out for fold 2 (lr=0.005, num_epochs =150)



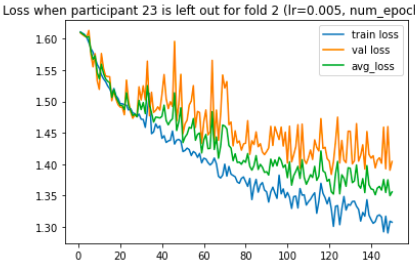
Loss when participant 22 is left out for fold 3 (lr=0.005, num_epochs =150)

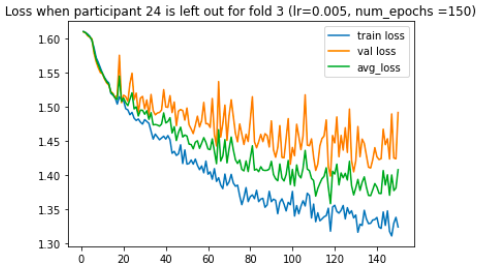


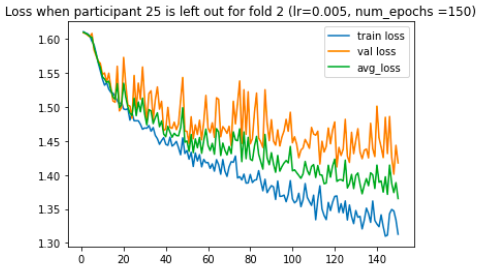
Loss when participant 19 is left out for fold 1 (lr=0.005, num_epochs =150)



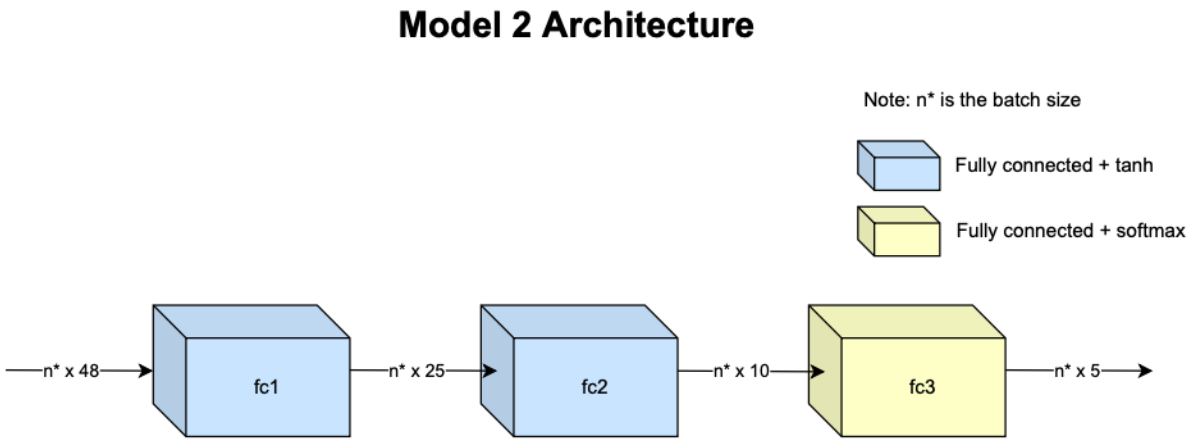
Loss when participant 23 is left out for fold 2 (lr=0.005, num_epochs =150)







MODEL 2: MODEL WITH 3 LINEAR Layers (USED ONLY EMG FEATURES AS INPUT – 48 FEATURES)

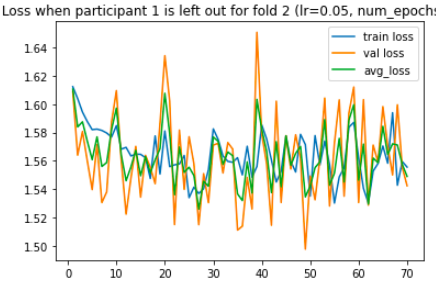


Confusion matrix	Average Micro F1 score	Average Macro F1 score	Overall accuracy
[[99 23 37 80 13] [75 25 26 100 26] [73 24 46 85 24] [30 25 39 130 28] [42 30 45 116 19]]	0.25	0.17	25.32%

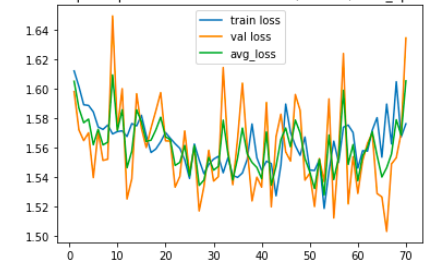
Participant left out	Confusion matrix	Micro F1 score	Macro F1 score	Classification accuracy
1	[[8 5 5 0 0] [7 7 1 3 0] [16 0 2 0 0] [0 9 1 8 0] [2 10 1 5 0]]	0.28	0.24	27.78%
2	[[0 5 0 13 0] [0 2 0 16 0] [0 18 0 0 0] [0 1 0 17 0] [0 4 0 14 0]]	0.21	0.1	21.11%
3	[[17 1 0 0 0] [5 9 0 3 1] [10 0 2 6 0] [1 9 0 6 2] [7 9 0 1 1]]	0.39	0.32	38.89%
4	[[0 0 0 16 2] [0 0 0 18 0] [0 0 0 18 0] [0 0 0 17 1] [0 0 0 18 0]]	0.19	0.06	18.89%
5	[[0 0 5 13 0] [0 0 0 18 0] [0 0 3 15 0] [0 0 0 18 0] [0 0 0 18 0]]	0.23	0.12	23.33%
6	[[6 2 10 0 0] [8 0 10 0 0] [9 0 9 0 0] [2 2 14 0 0] [0 0 18 0 0]]	0.17	0.1	16.67%
7	[[12 0 6 0 0] [14 1 1 0 2] [14 0 4 0 0] [9 0 3 5 1] [4 0 0 11 3]]	0.28	0.25	27.78%
8	[[17 0 1 0 0] [14 0 4 0 0] [17 0 1 0 0] [7 0 5 6 0] [4 0 10 4 0]]	0.27	0.18	26.67%

19	[[9 0 6 0 3] [3 0 0 0 15] [1 0 1 0 16] [0 0 0 0 18] [4 0 5 0 9]]	0.21	0.16	21.11%
21	[[0 0 1 11 6] [0 0 0 10 8] [0 0 0 12 6] [0 0 0 14 4] [0 0 0 12 6]]	0.22	0.12	22.22%
22	[[12 2 3 0 1] [9 2 7 0 0] [3 2 12 0 1] [3 2 11 1 1] [6 4 8 0 0]]	0.3	0.22	30.0%
23	[[0 8 0 9 1] [0 4 0 14 0] [0 4 0 14 0] [0 1 0 16 1] [0 3 0 15 0]]	0.22	0.12	22.22%
24	[[18 0 0 0 0] [15 0 3 0 0] [3 0 12 2 1] [8 1 5 4 0] [15 0 3 0 0]]	0.38	0.28	37.78%
25	[[0 0 0 18 0] [0 0 0 18 0] [0 0 0 18 0] [0 0 0 18 0] [0 0 0 18 0]]	0.2	0.07	20.0%

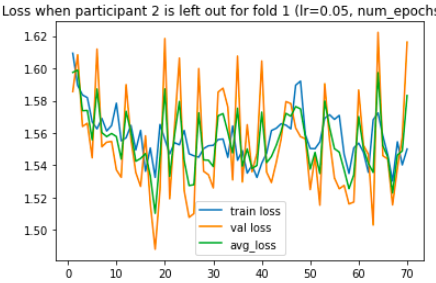
Loss when participant 1 is left out for fold 2 (lr=0.05, num_epochs =70)



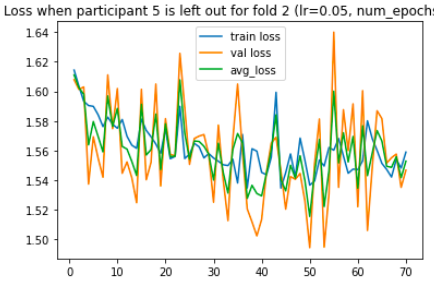
Loss when participant 4 is left out for fold 2 (lr=0.05, num_epochs =70)



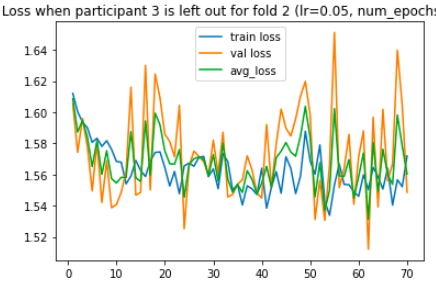
Loss when participant 2 is left out for fold 1 (lr=0.05, num_epochs =70)



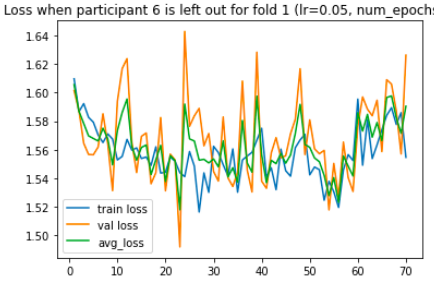
Loss when participant 5 is left out for fold 2 (lr=0.05, num_epochs =70)



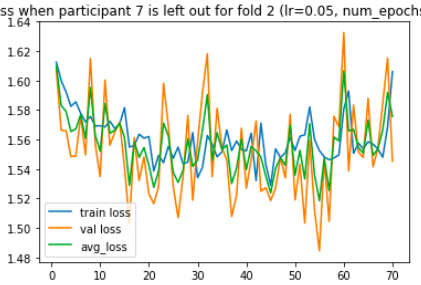
Loss when participant 3 is left out for fold 2 (lr=0.05, num_epochs =70)



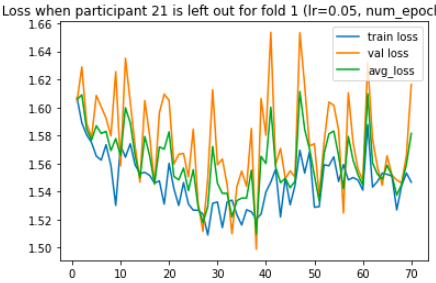
Loss when participant 6 is left out for fold 1 (lr=0.05, num_epochs =70)



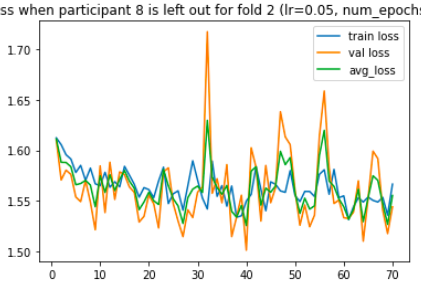
Loss when participant 7 is left out for fold 2 (lr=0.05, num_epochs =70)



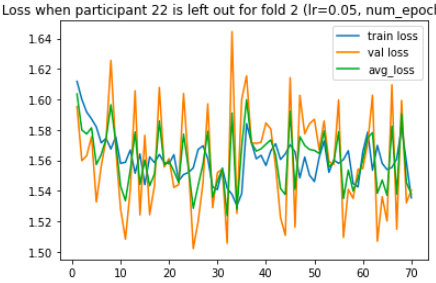
Loss when participant 21 is left out for fold 1 (lr=0.05, num_epochs =70)



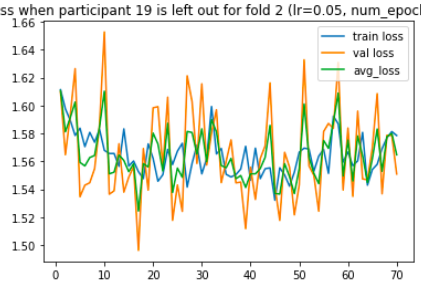
Loss when participant 8 is left out for fold 2 (lr=0.05, num_epochs =70)



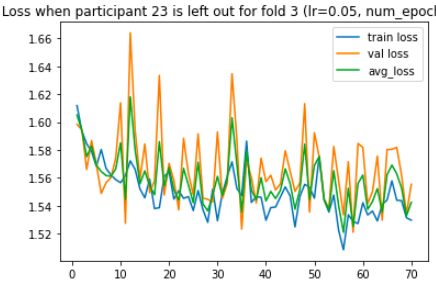
Loss when participant 22 is left out for fold 2 (lr=0.05, num_epochs =70)



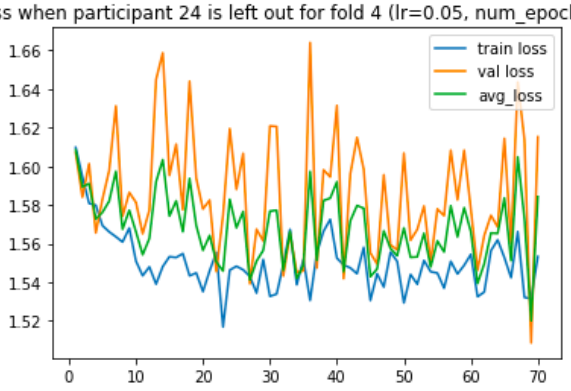
Loss when participant 19 is left out for fold 2 (lr=0.05, num_epochs =70)



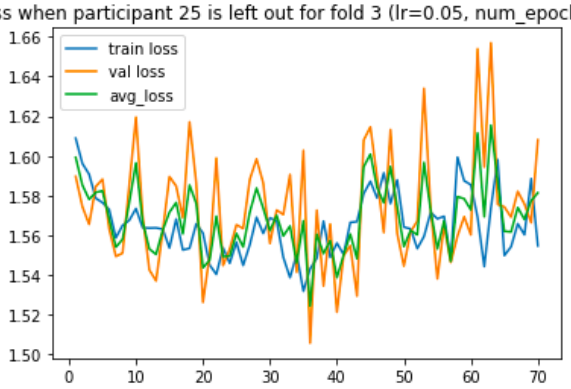
Loss when participant 23 is left out for fold 3 (lr=0.05, num_epochs =70)



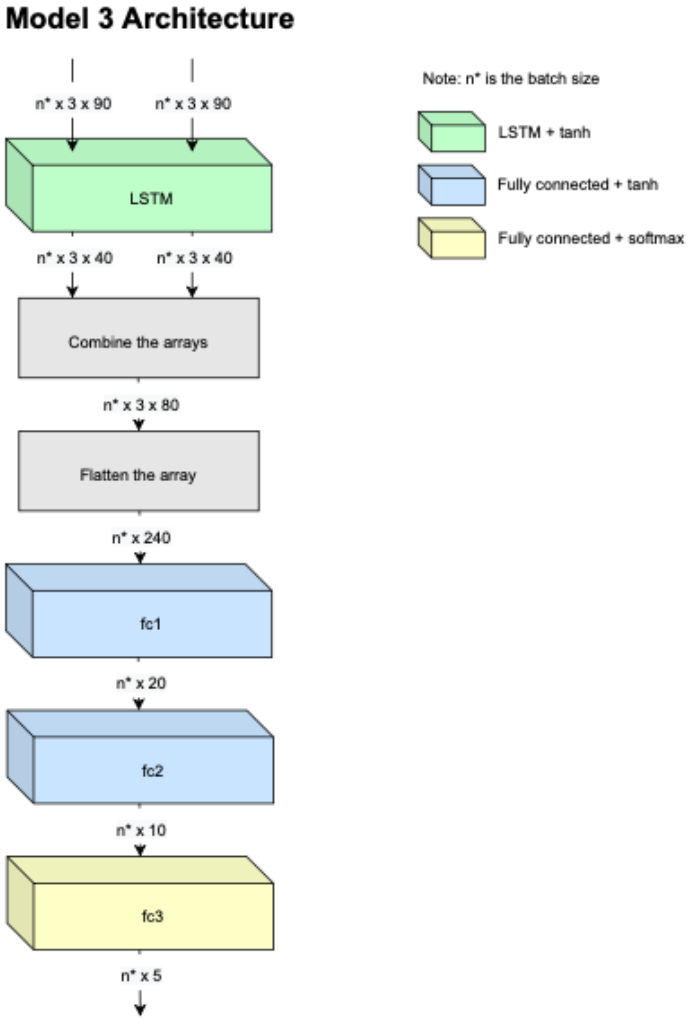
Loss when participant 24 is left out for fold 4 (lr=0.05, num_epochs =70)



Loss when participant 25 is left out for fold 3 (lr=0.05, num_epochs =70)



MODEL 3: MODEL WITH AN LSTM LAYER + LINEAR FEATURES (USED ALL 180 FEATURES AS INPUT

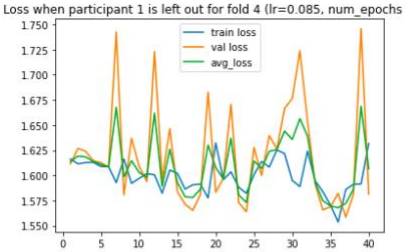


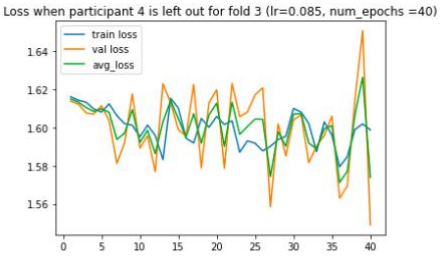
Confusion matrix	Average Micro F1 score	Average Macro F1 score	Overall accuracy
[[28 8 33 14 1] [23 7 37 16 1] [26 6 27 23 2] [14 6 29 30 5] [18 6 37 20 3]]	0.23	0.12	22.62%

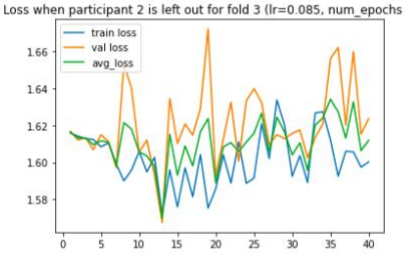
Participant left out	Confusion matrix	Micro F1 score	Macro F1 score	Classification accuracy

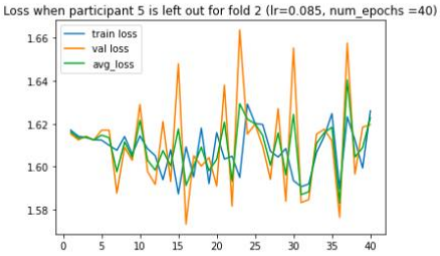
1	[[3 3 0 0 0] [3 2 1 0 0] [2 4 0 0 0] [2 0 4 0 0] [2 1 3 0 0]]	0.17	0.12	16.67%
2	[[3 0 1 2 0] [2 0 2 1 1] [6 0 0 0 0] [0 0 0 6 0] [1 0 1 3 1]]	0.33	0.25	33.33%
3	[[0 0 6 0 0] [0 0 6 0 0] [0 0 3 3 0] [0 0 3 3 0] [0 0 6 0 0]]	0.2	0.14	20.0%
4	[[4 0 2 0 0] [0 0 4 2 0] [2 0 0 4 0] [0 0 0 6 0] [0 0 2 4 0]]	0.33	0.24	33.33%
5	[[0 0 6 0 0] [0 0 6 0 0] [0 0 6 0 0] [0 0 6 0 0] [0 0 6 0 0]]	0.2	0.07	20.0%
6	[[0 0 0 6 0] [0 0 0 6 0] [0 0 0 6 0] [0 0 0 6 0] [0 0 0 6 0]]	0.2	0.07	20.0%
7	[[6 0 0 0 0] [6 0 0 0 0] [6 0 0 0 0] [6 0 0 0 0] [6 0 0 0 0]]	0.2	0.07	20.0%
8	[[6 0 0 0 0] [6 0 0 0 0] [6 0 0 0 0] [3 2 0 1 0] [5 0 1 0 0]]	0.23	0.13	23.33%
19	[[0 0 6 0 0] [0 0 6 0 0] [0 0 6 0 0]	0.2	0.07	20.0%

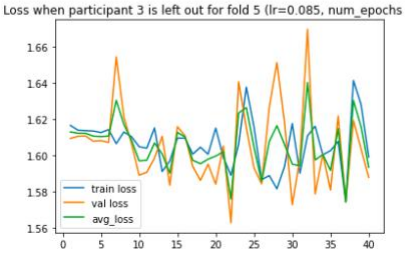
	[0 0 4 0 2] [0 0 6 0 0]]			
21	[[0 0 6 0 0] [0 0 6 0 0] [0 0 6 0 0] [0 0 6 0 0] [0 0 6 0 0]]	0.2	0.07	20.0%
22	[[5 0 0 0 1] [6 0 0 0 0] [4 0 0 0 2] [3 0 0 0 3] [4 0 0 0 2]]	0.23	0.13	23.33%
23	[[0 0 6 0 0] [0 0 6 0 0] [0 0 6 0 0] [0 0 6 0 0] [0 0 6 0 0]]	0.2	0.07	20.0%
24	[[1 5 0 0 0] [0 5 0 1 0] [0 2 0 4 0] [0 4 0 2 0] [0 5 0 1 0]]	0.27	0.19	26.67%
25	[[0 0 0 6 0] [0 0 0 6 0] [0 0 0 6 0] [0 0 0 6 0] [0 0 0 6 0]]	0.2	0.07	20.0%

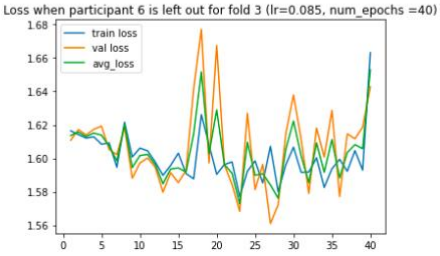

Loss when participant 1 is left out for fold 4 (lr=0.085, num_epochs =40)
train loss
val loss
avg_loss

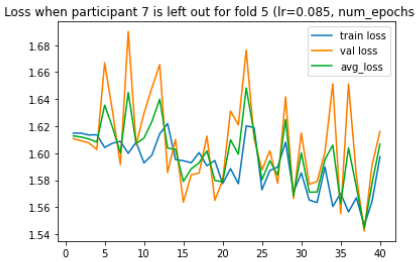

Loss when participant 4 is left out for fold 3 (lr=0.085, num_epochs =40)
train loss
val loss
avg_loss

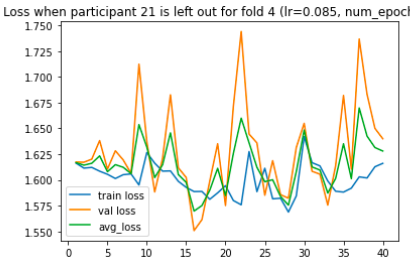

Loss when participant 2 is left out for fold 3 (lr=0.085, num_epochs =40)
train loss
val loss
avg_loss

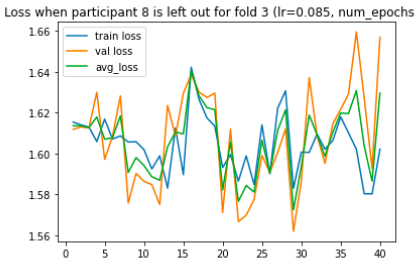

Loss when participant 5 is left out for fold 2 (lr=0.085, num_epochs =40)
train loss
val loss
avg_loss

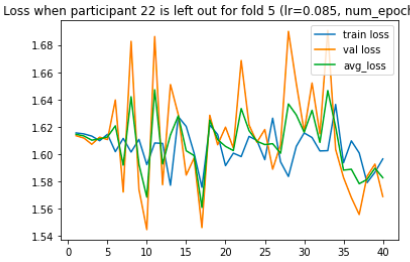

Loss when participant 3 is left out for fold 5 (lr=0.085, num_epochs =40)
train loss
val loss
avg_loss

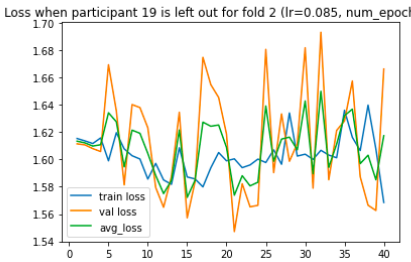

Loss when participant 6 is left out for fold 3 (lr=0.085, num_epochs =40)
train loss
val loss
avg_loss

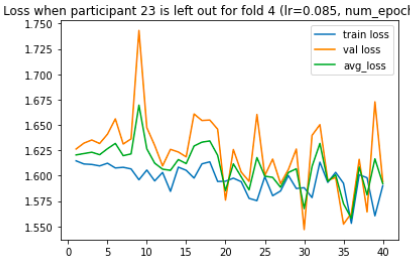

Loss when participant 7 is left out for fold 5 (lr=0.085, num_epochs =40)
train loss
val loss
avg_loss

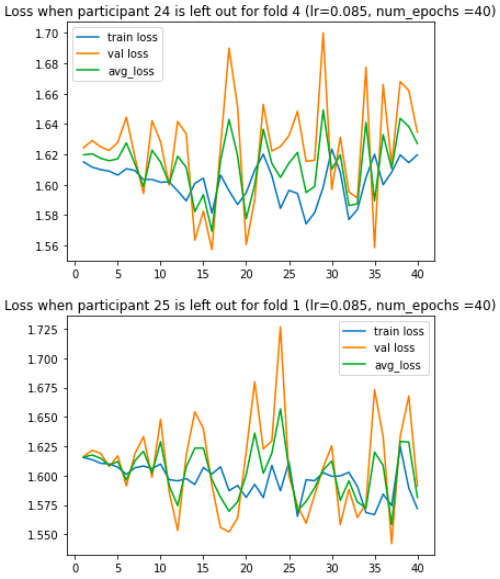

Loss when participant 21 is left out for fold 4 (lr=0.085, num_epochs =40)
train loss
val loss
avg_loss


Loss when participant 8 is left out for fold 3 (lr=0.085, num_epochs =40)
train loss
val loss
avg_loss


Loss when participant 22 is left out for fold 5 (lr=0.085, num_epochs =40)
train loss
val loss
avg_loss

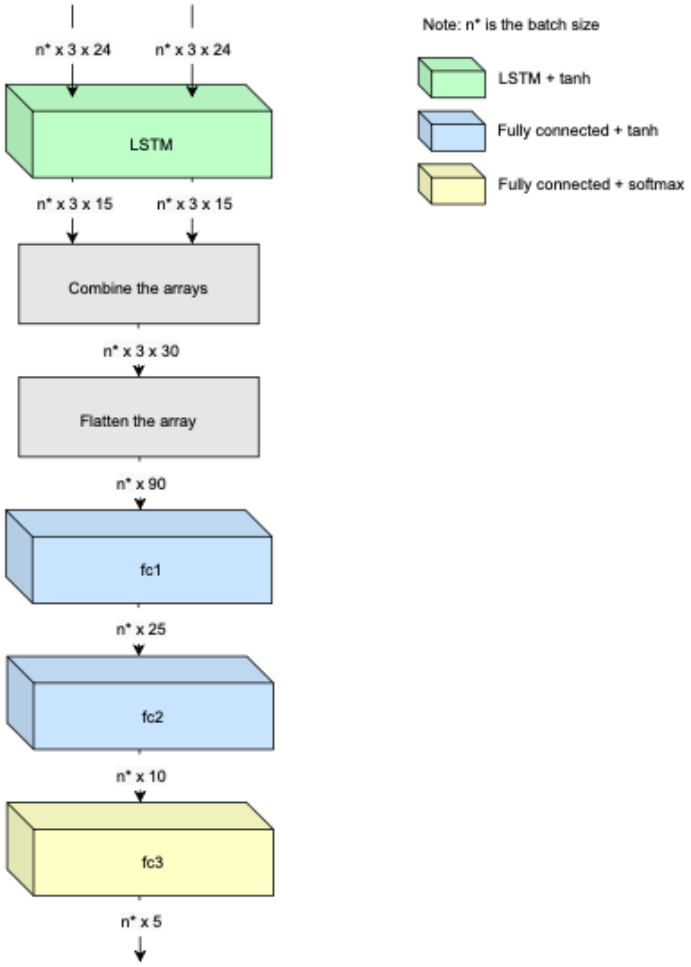

Loss when participant 19 is left out for fold 2 (lr=0.085, num_epochs =40)
train loss
val loss
avg_loss


Loss when participant 23 is left out for fold 4 (lr=0.085, num_epochs =40)
train loss
val loss
avg_loss



MODEL 4: MODEL WITH AN LSTM LAYER + LINEAR FEATURES (USED ONLY EMG FEATURES AS INPUT – 48 FEATURES)

Model 4 Architecture



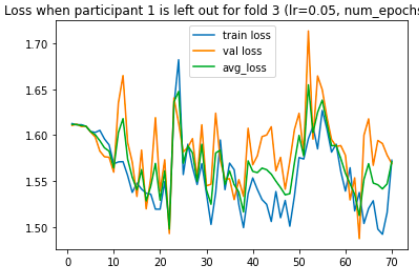
Confusion matrix	Average Micro F1 score	Average Macro F1 score	Overall accuracy
[[15 26 12 13 18] [9 13 15 32 15] [18 19 16 17 14] [6 8 11 35 24] [10 11 11 33 19]]	0.23	0.15	23.33%

Participant left out	Confusion matrix	Micro F1 score	Macro F1 score	Classification accuracy
1	[[6 0 0 0 0] [3 0 0 0 3] [6 0 0 0 0] [1 0 0 0 5]	0.3	0.17	30.0%

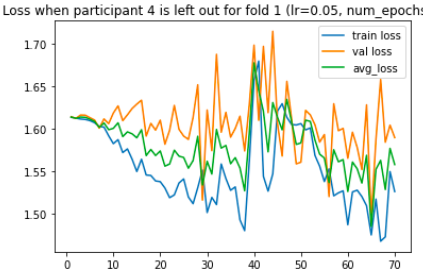
	[3 0 0 0 3]]			
2	[[0 0 2 2 2] [0 0 3 2 1] [6 0 0 0 0] [0 1 1 1 3] [0 1 1 3 1]]	0.07	0.06	6.67%
3	[[1 5 0 0 0] [0 1 0 5 0] [3 0 1 2 0] [0 0 0 6 0] [1 1 0 4 0]]	0.3	0.23	30.0%
4	[[0 0 0 2 4] [0 0 0 6 0] [0 0 0 5 1] [0 0 0 6 0] [0 0 0 6 0]]	0.2	0.08	20.0%
5	[[0 3 2 1 0] [0 0 0 6 0] [0 2 0 4 0] [0 0 0 6 0] [0 0 0 6 0]]	0.2	0.08	20.0%
6	[[0 0 0 1 5] [0 0 0 2 4] [0 1 0 1 4] [0 0 0 0 6] [0 0 0 0 6]]	0.2	0.08	20.0%
7	[[2 3 1 0 0] [2 1 3 0 0] [2 1 3 0 0] [1 2 2 0 1] [0 0 4 2 0]]	0.2	0.16	20.0%
8	[[0 6 0 0 0] [0 6 0 0 0] [0 6 0 0 0] [0 3 1 2 0] [0 3 1 1 1]]	0.3	0.23	30.0%
19	[[0 5 0 1 0] [0 3 0 3 0] [0 2 1 3 0] [0 0 0 6 0] [0 4 0 2 0]]	0.33	0.23	33.33%

21	[[0 0 0 0 6] [0 0 0 0 6] [0 0 0 0 6] [0 0 0 0 6] [0 0 0 0 6]]	0.2	0.07	20.0%
22	[[1 0 2 2 1] [0 0 6 0 0] [0 1 4 0 1] [0 0 3 2 1] [0 0 3 2 1]]	0.27	0.23	26.67%
23	[[0 3 0 3 0] [0 1 1 4 0] [0 5 0 1 0] [0 2 0 4 0] [0 2 0 4 0]]	0.17	0.09	16.67%
24	[[5 1 0 0 0] [4 1 0 0 1] [1 1 1 1 2] [4 0 0 0 2] [6 0 0 0 0]]	0.23	0.18	23.33%
25	[[0 0 5 1 0] [0 0 2 4 0] [0 0 6 0 0] [0 0 4 2 0] [0 0 2 3 1]]	0.3	0.2	30.0%

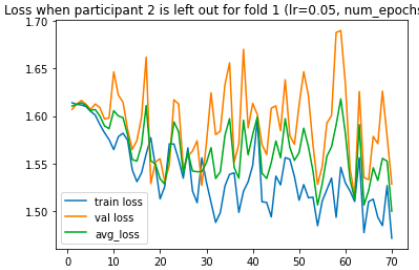
Loss when participant 1 is left out for fold 3 (lr=0.05, num_epochs =70)



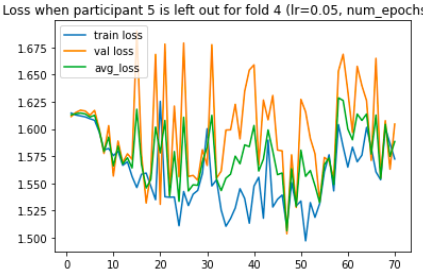
Loss when participant 4 is left out for fold 1 (lr=0.05, num_epochs =70)



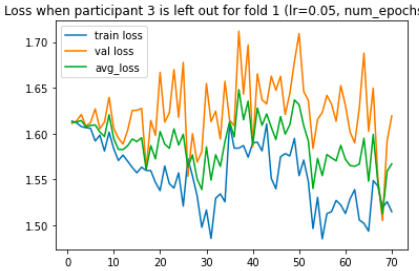
Loss when participant 2 is left out for fold 1 (lr=0.05, num_epochs =70)



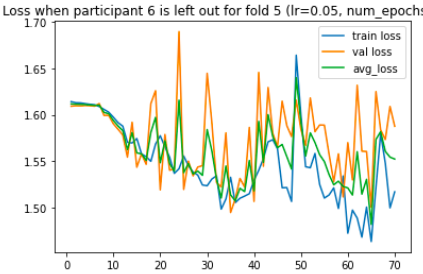
Loss when participant 5 is left out for fold 4 (lr=0.05, num_epochs =70)



Loss when participant 3 is left out for fold 1 (lr=0.05, num_epochs =70)

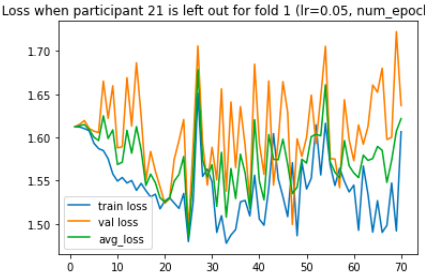


Loss when participant 6 is left out for fold 5 (lr=0.05, num_epochs =70)

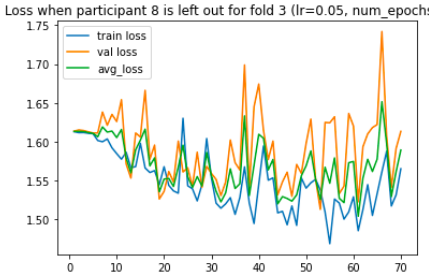


Loss when participant 7 is left out for fold 1 (lr=0.05, num_epochs =70)

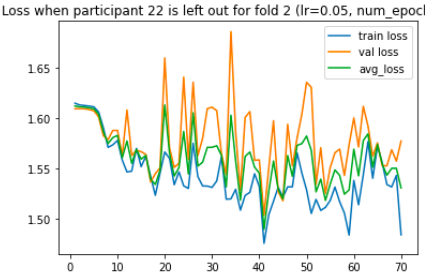
Loss when participant 21 is left out for fold 1 (lr=0.05, num_epochs =70)



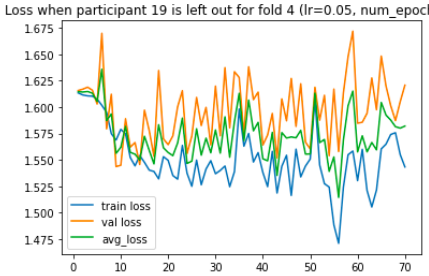
Loss when participant 8 is left out for fold 3 (lr=0.05, num_epochs =70)



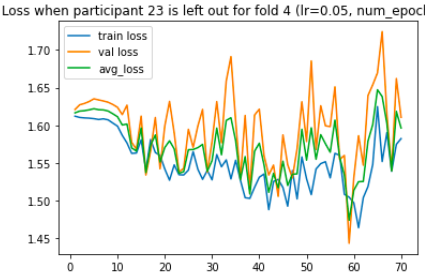
Loss when participant 22 is left out for fold 2 (lr=0.05, num_epochs =70)



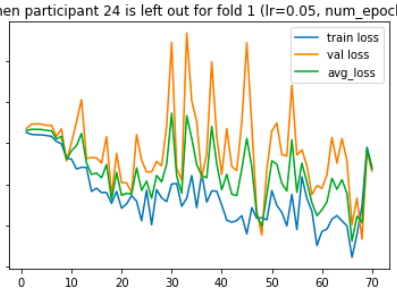
Loss when participant 19 is left out for fold 4 (lr=0.05, num_epochs =70)



Loss when participant 23 is left out for fold 4 (lr=0.05, num_epochs =70)



Loss when participant 24 is left out for fold 1 (lr=0.05, num_epochs =70)



Loss when participant 25 is left out for fold 4 (lr=0.05, num_epochs =70)