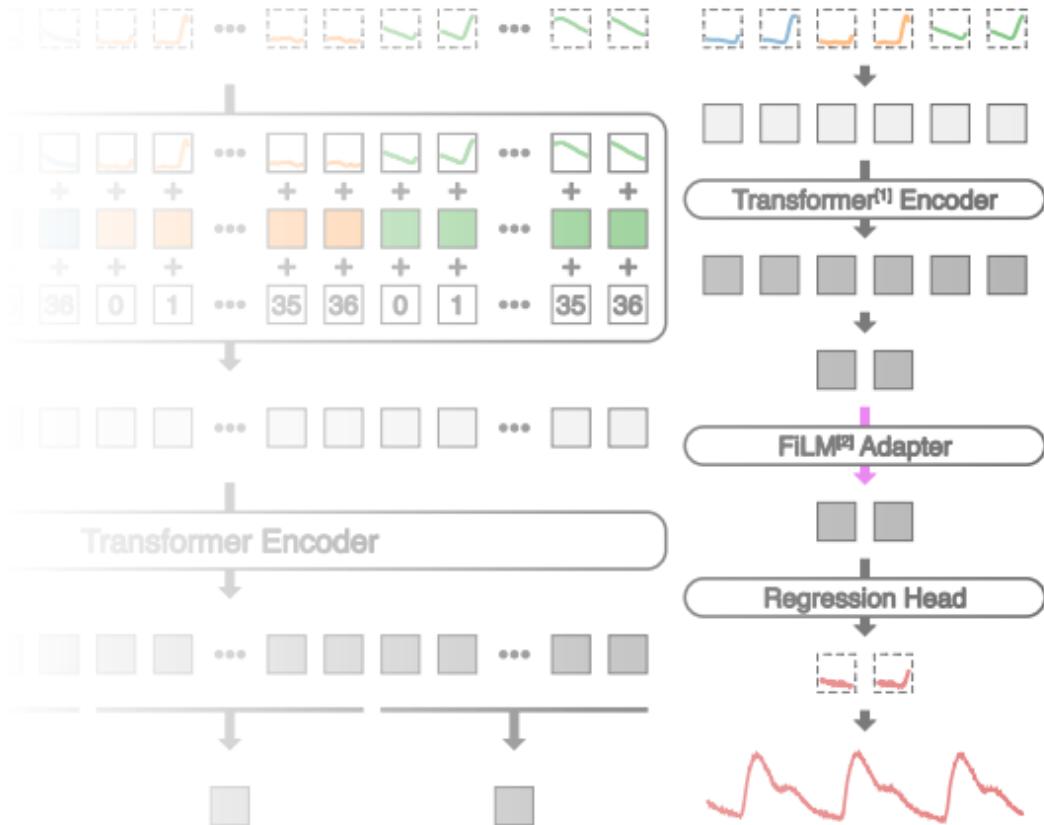


dimension	channel
100	ch1: Finger 808nm BFI
256	ch2: Finger 808nm PPG ch3: Wrist 808nm BFI

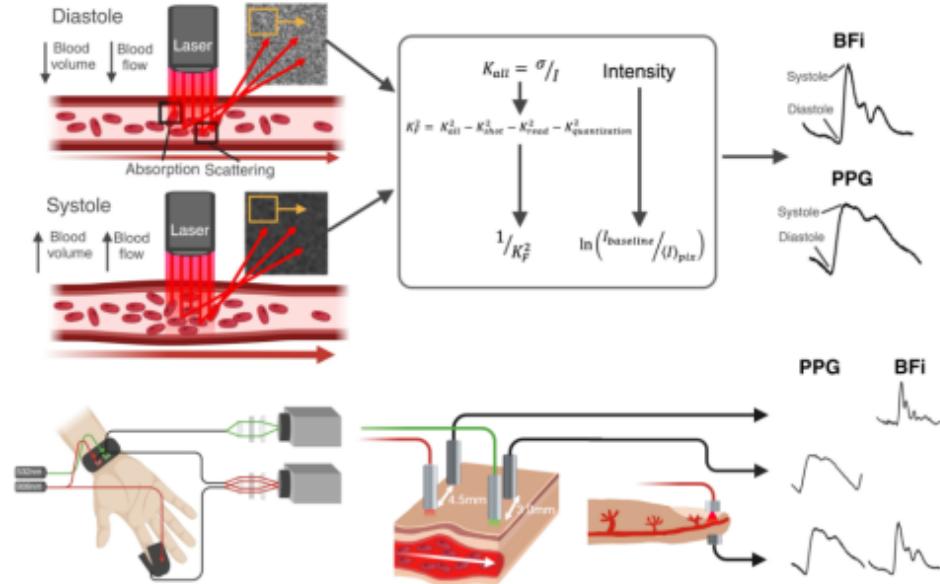
# Transformer-Based Cuffless Blood Pressure Estimation

Driven by Speckle Contrast  
Optical Spectroscopy (SCOS)

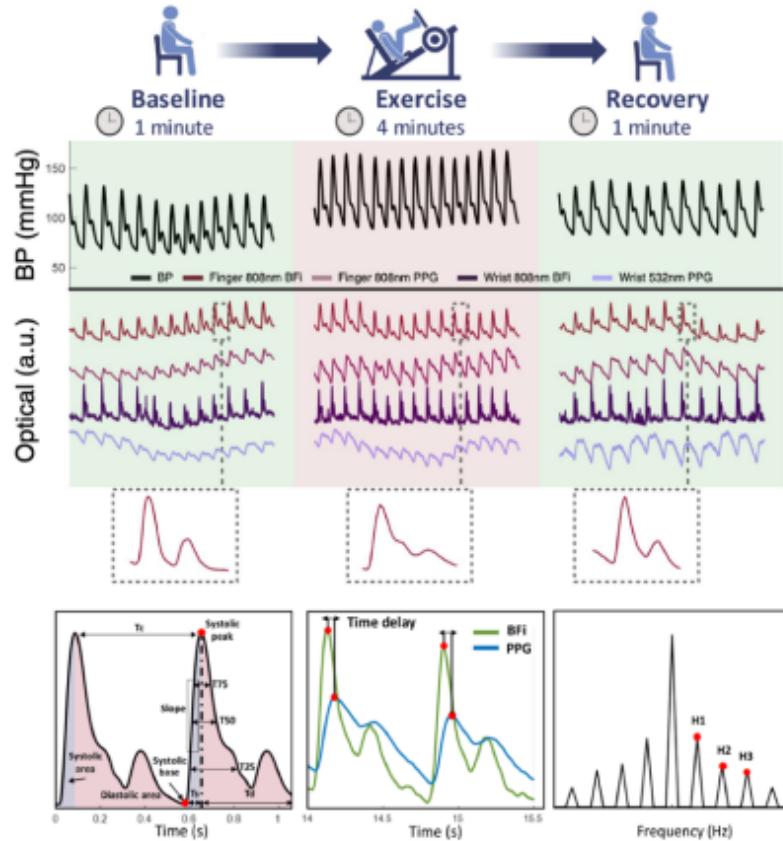
Tianrui Qi  
Dec 12, 2025



# Background



Garrett, A. et al. Biomed. Opt. Express 16, 3004–3016 (2025).



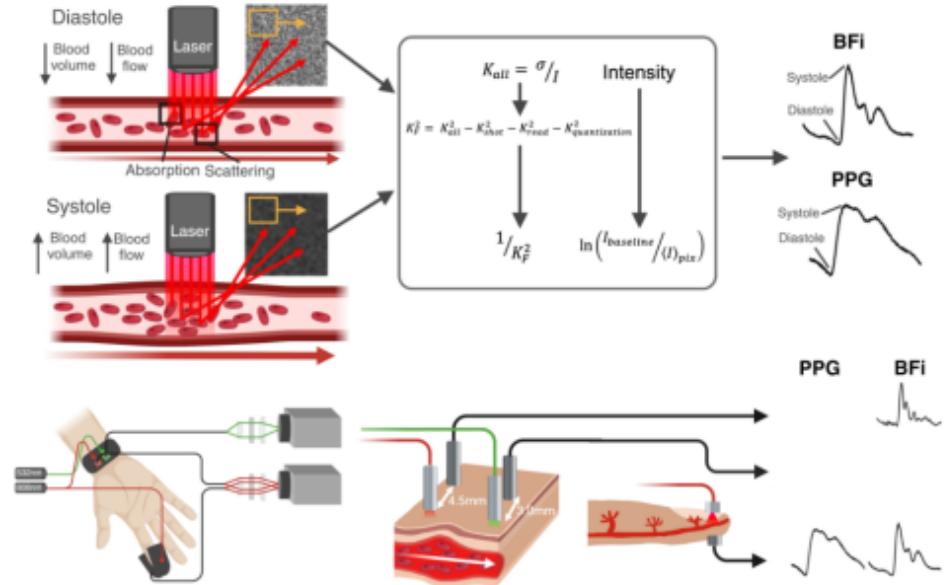
Garrett, A. et al. Biomed. Opt. Express 16, 3004–3016 (2025).



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# Data: Preparation



Garrett, A. et al. Biomed. Opt. Express 16, 3004–3016 (2025).

## Measurement

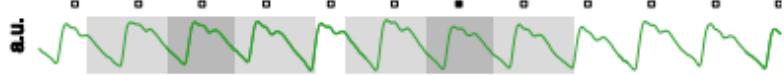
Finger 808nm BFI



Finger 808nm PPG



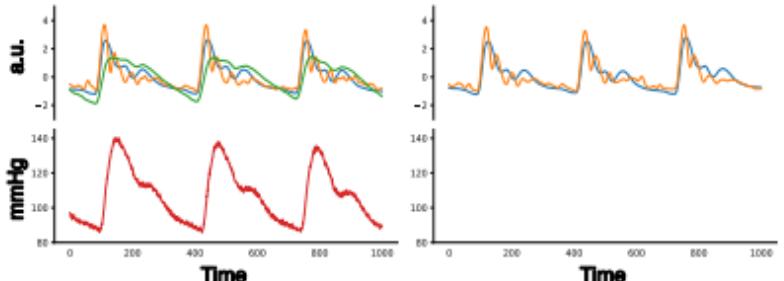
Wrist 808nm BFI



Blood Pressure



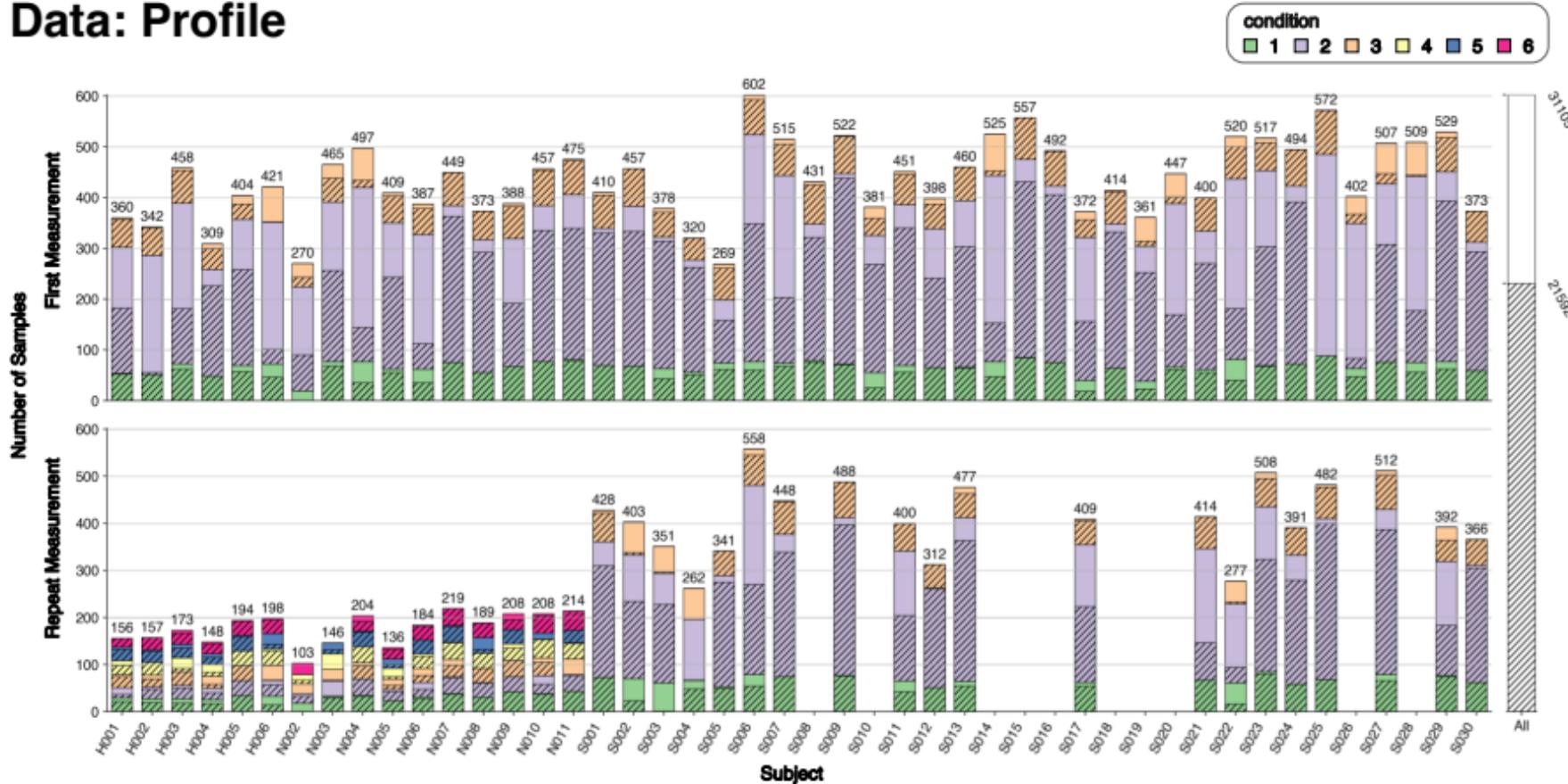
## Sample



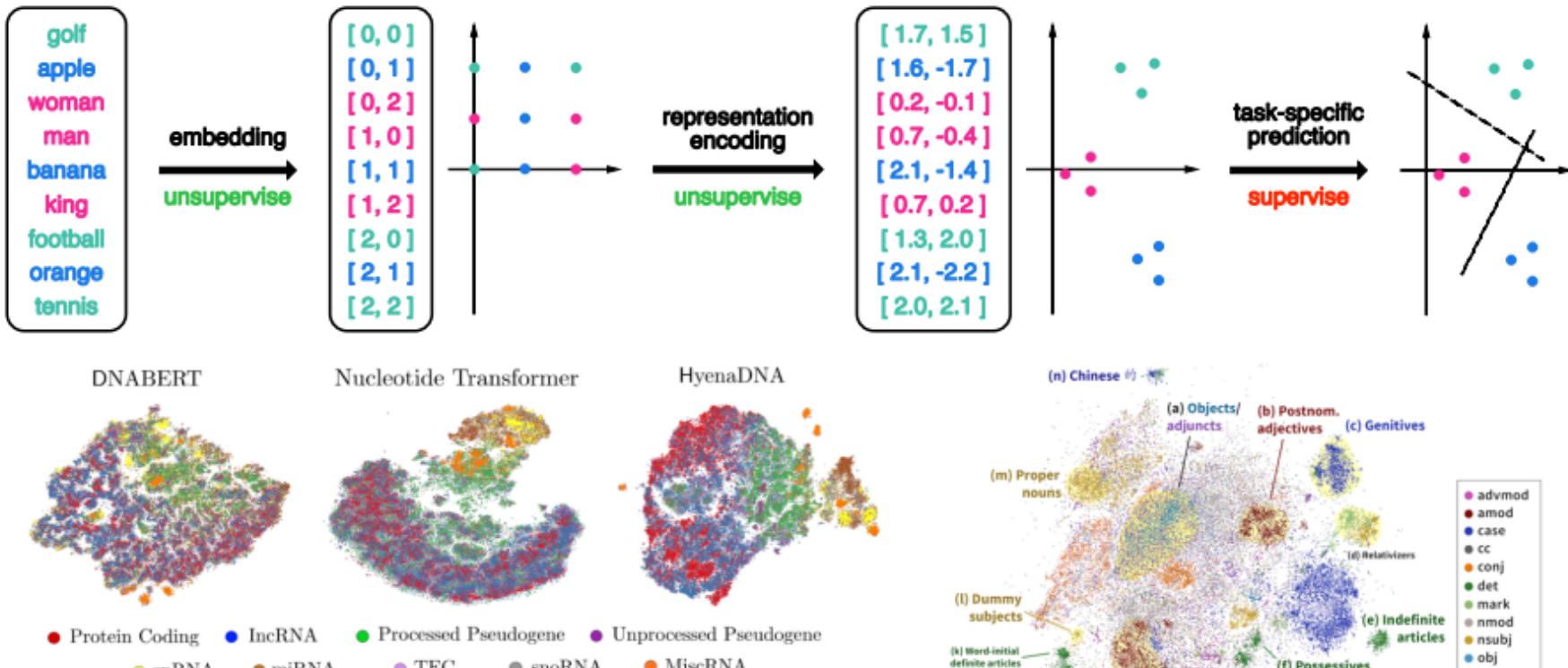
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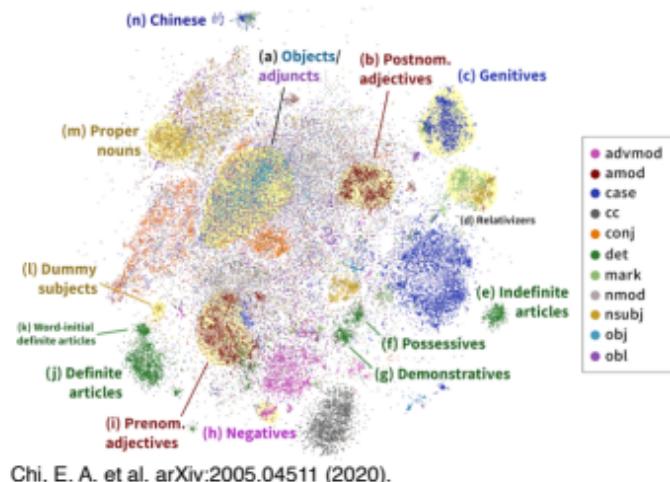
# Data: Profile



# Model: Representation Learning



Nguyen, E. et al. arXiv:2306.15794 (2023).



Chi, E. A. et al. arXiv:2005.04511 (2020).



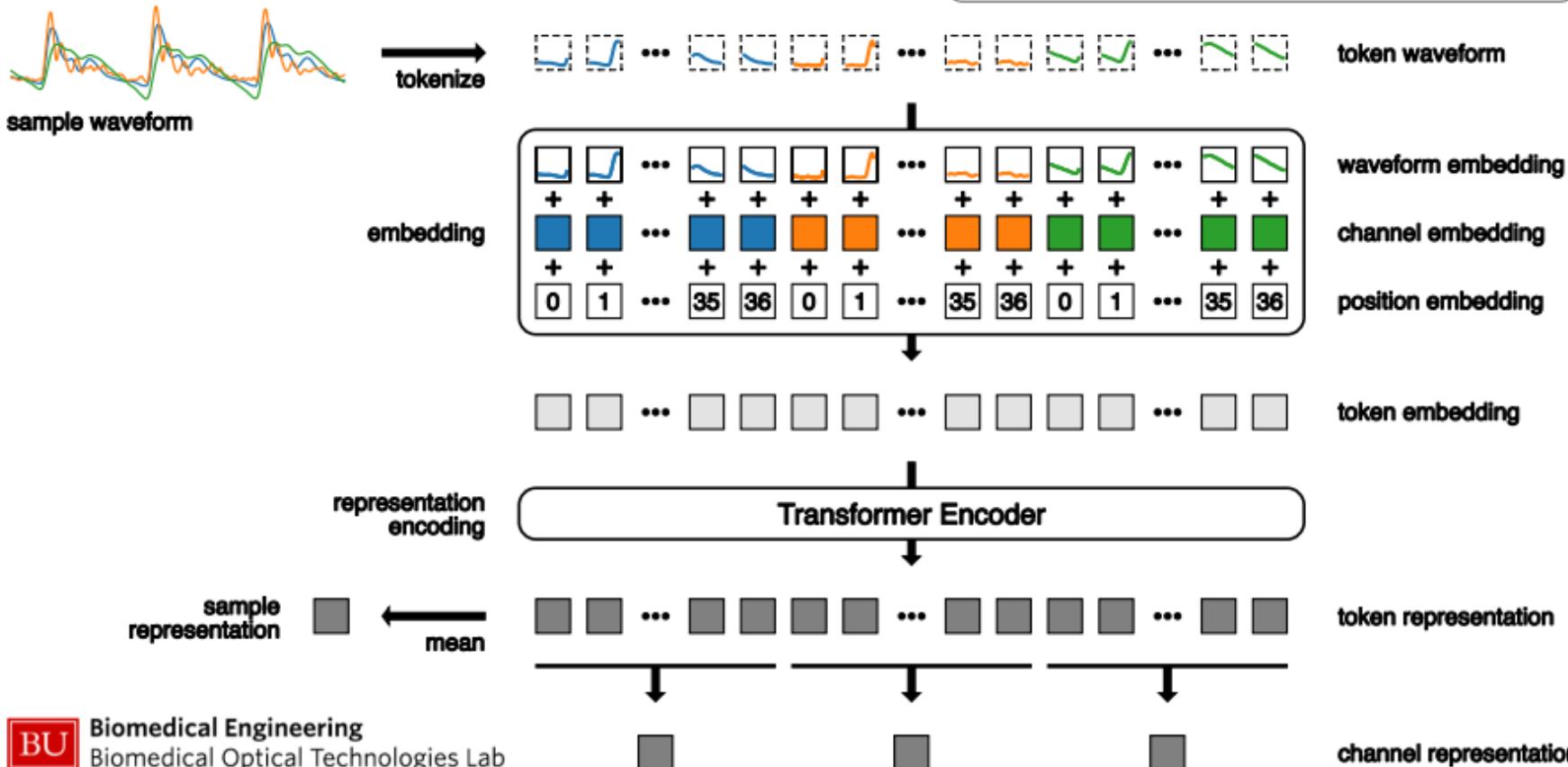
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# Model: Architecture

Yang, C. et al. BIOT: Cross-data biosignal learning in the wild. arXiv:2305.10351 (2023).

dimension	channel
100	ch1: Finger 808nm BFI
256	ch2: Finger 808nm PPG
	ch3: Wrist 808nm BFI



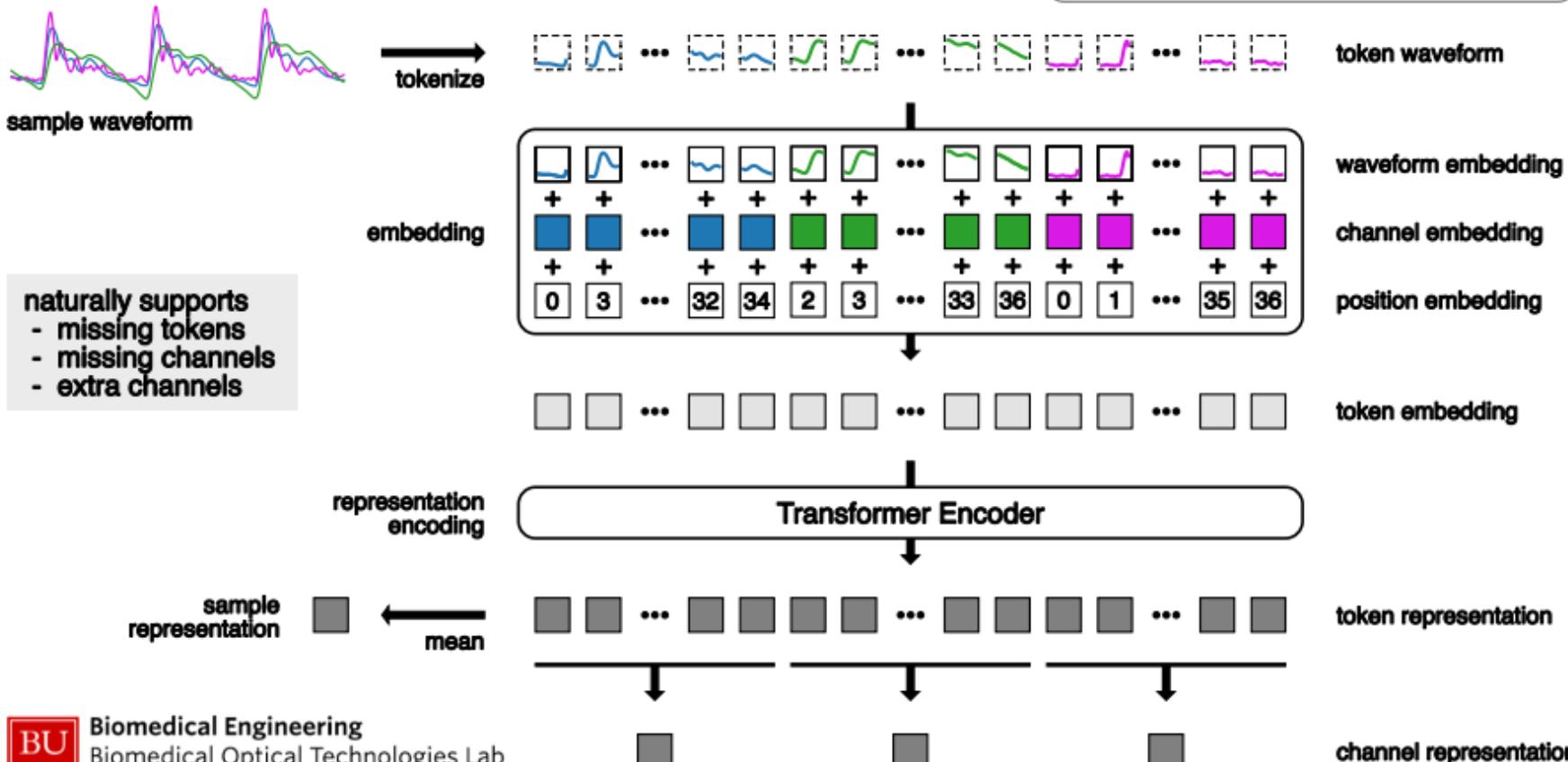
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# Model: Input Flexibility

Yang, C. et al. BIOT: Cross-data biosignal learning in the wild. arXiv:2305.10351 (2023).

dimension	channel
100	ch1: Finger 808nm BFI
256	ch2: missing ch3: Wrist 808nm BFI ch4: extra



# Model: Stage 1

[1] Vaswani, A. et al. Attention Is All You Need. arXiv:1706.03762 (2017).

↑ trainable → fixed

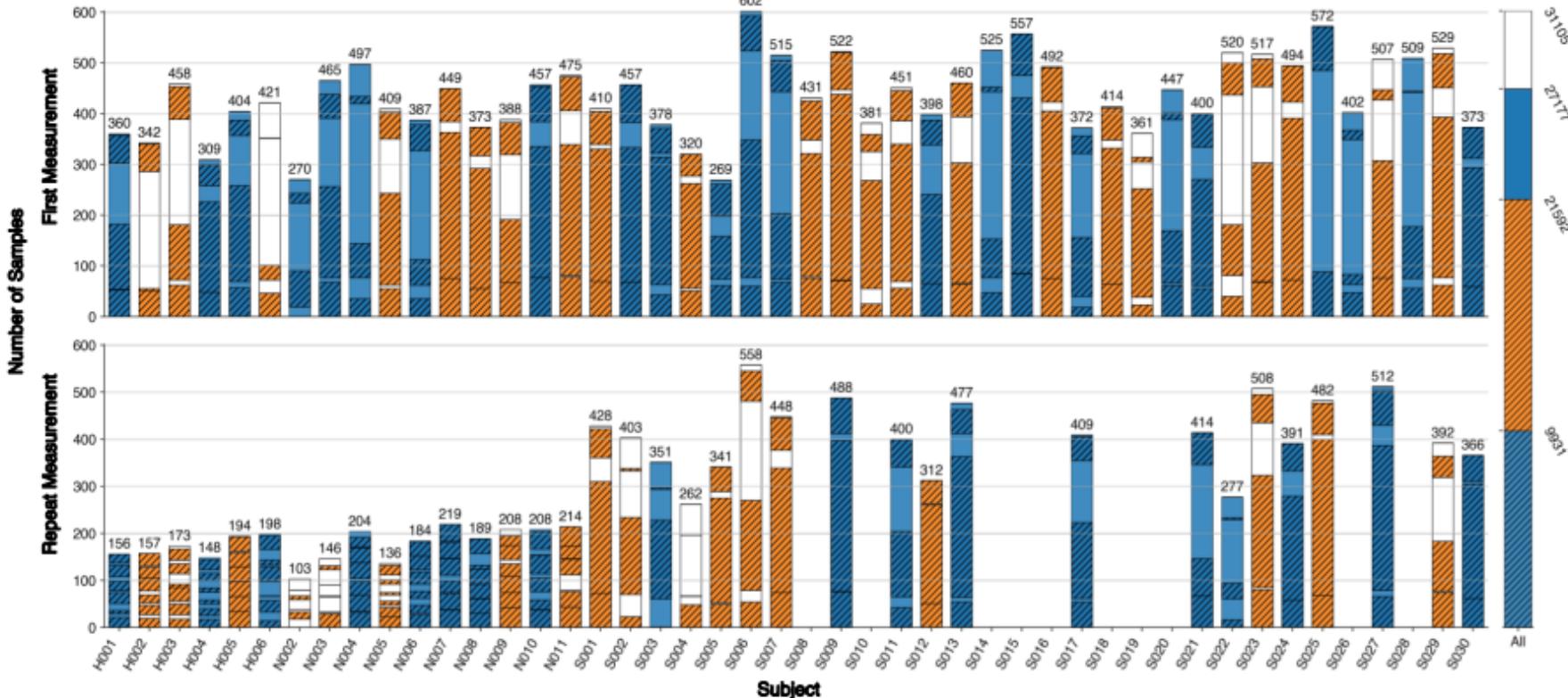


# Data: Stage 1 Split

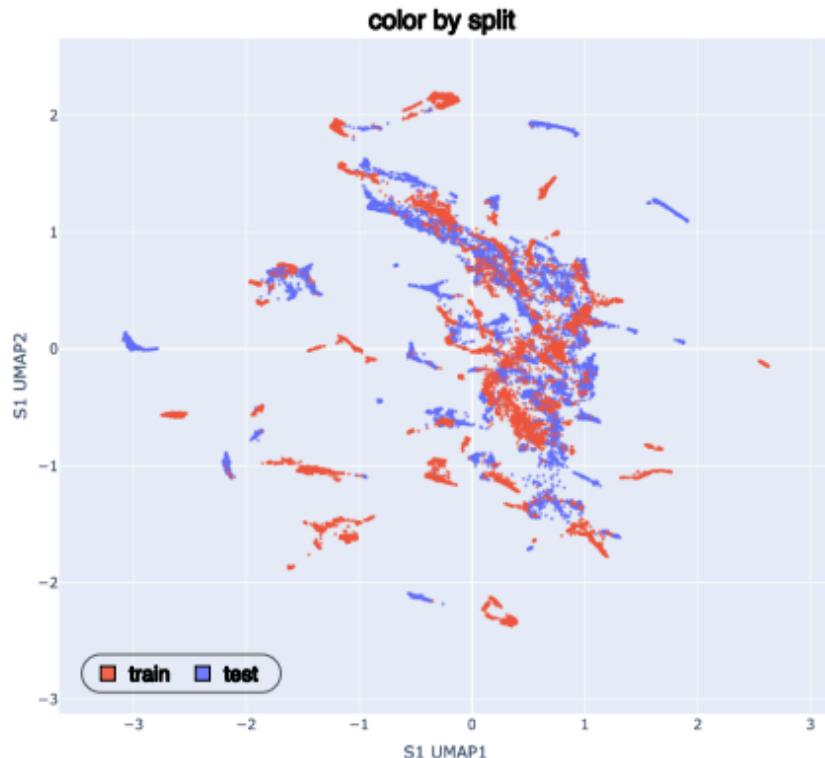
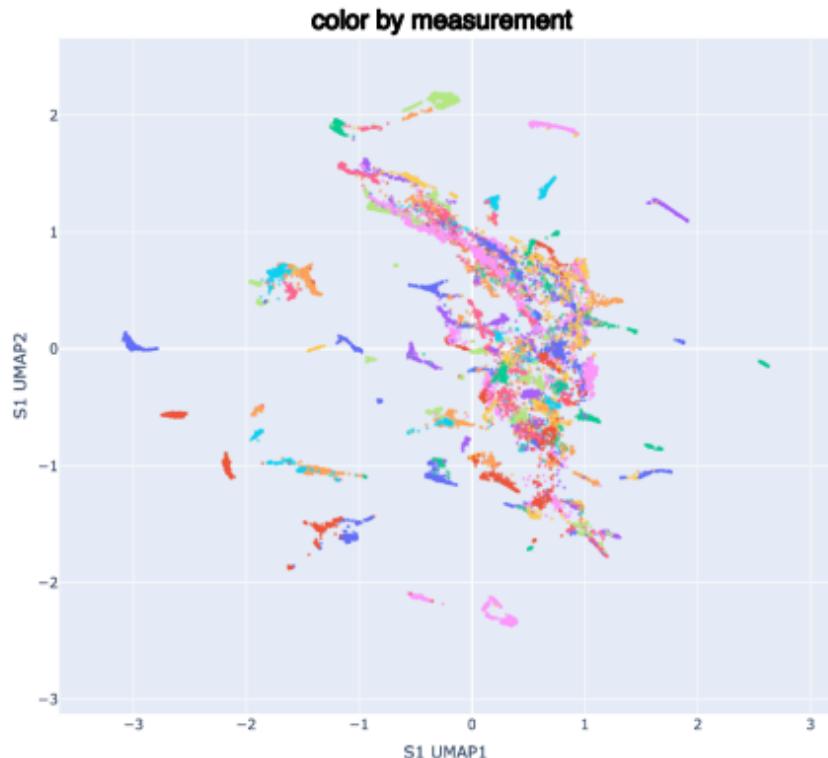
In implementation, we use (at least one optical ch passed QC), which adds ~1k more training samples.  
For simplicity, the figure below displays (BP & at least one optical ch passed QC).

Wang, Y. et al. How to evaluate your medical time series classification? arXiv 2410.03057 (2024).

split  
train test



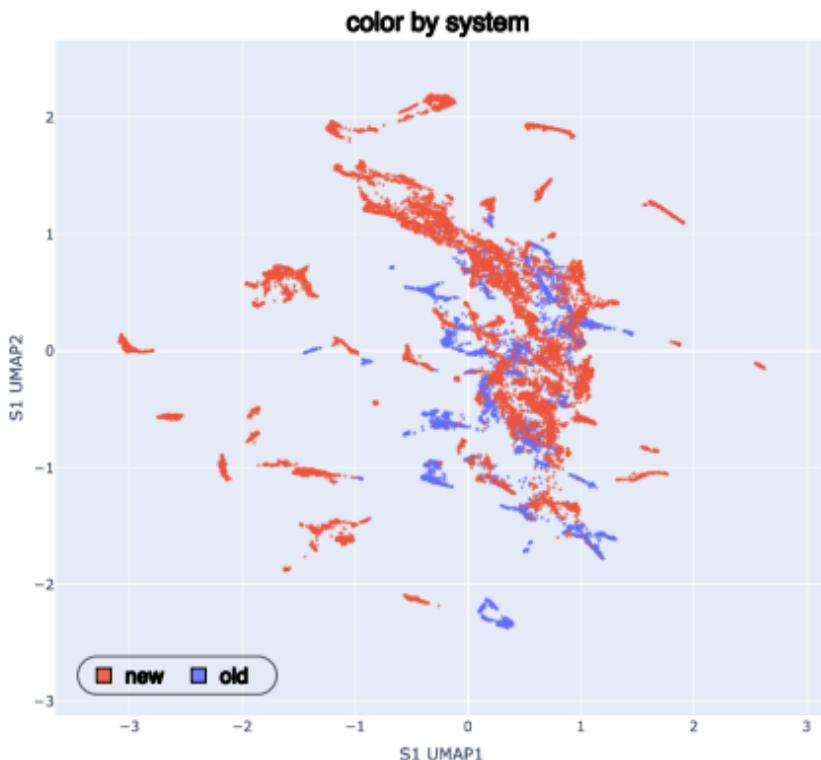
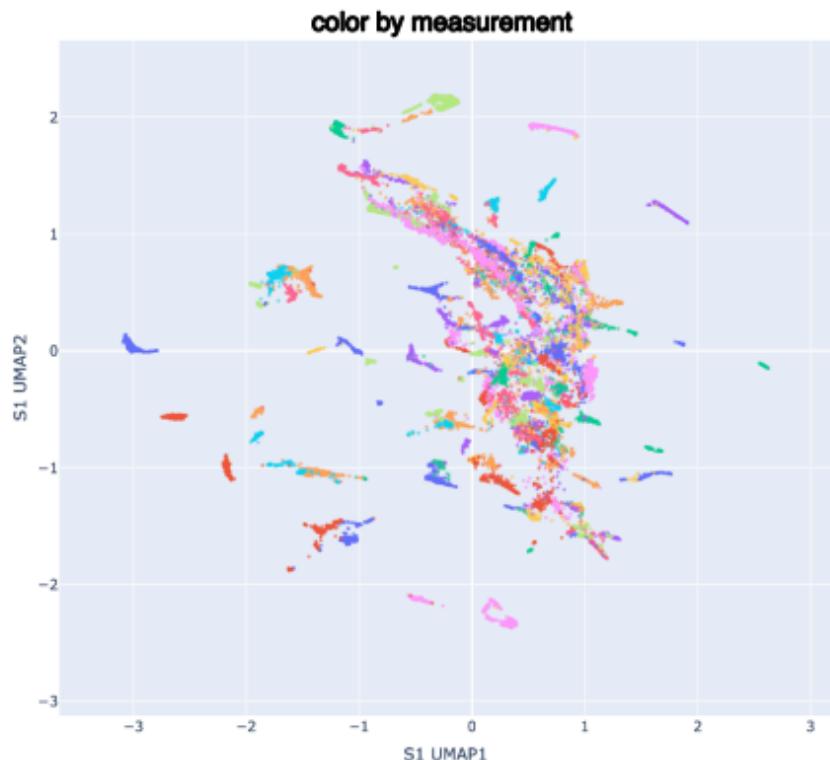
# Result: Stage 1 Representation generalizes well across train and test splits



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# Result: Stage 1 No clear separation between samples from old and new system

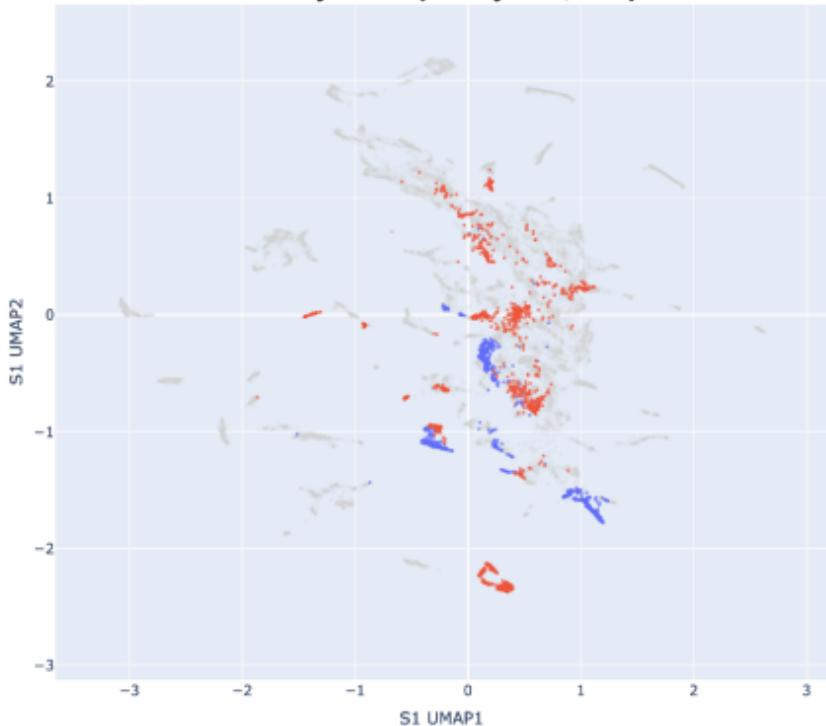


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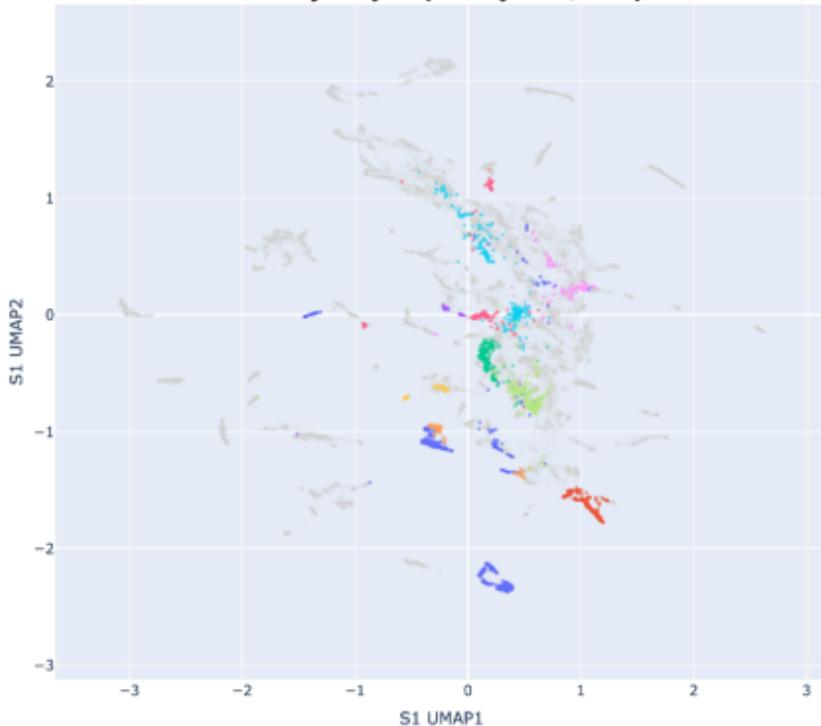
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# Result: Stage 1 With current number of subjects, health-related clustering is inconclusive

color by health (new system, train)



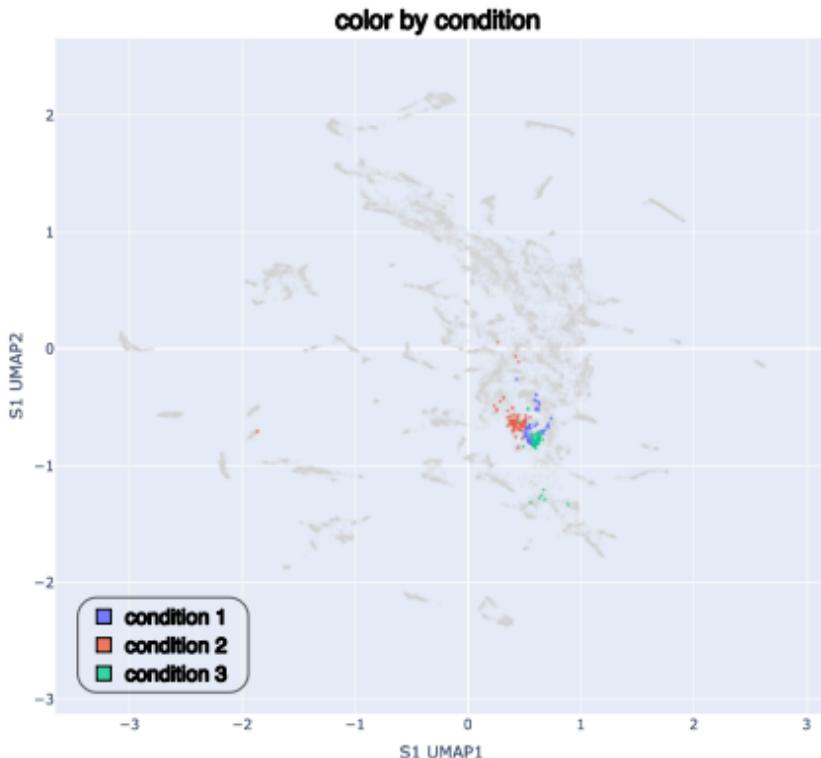
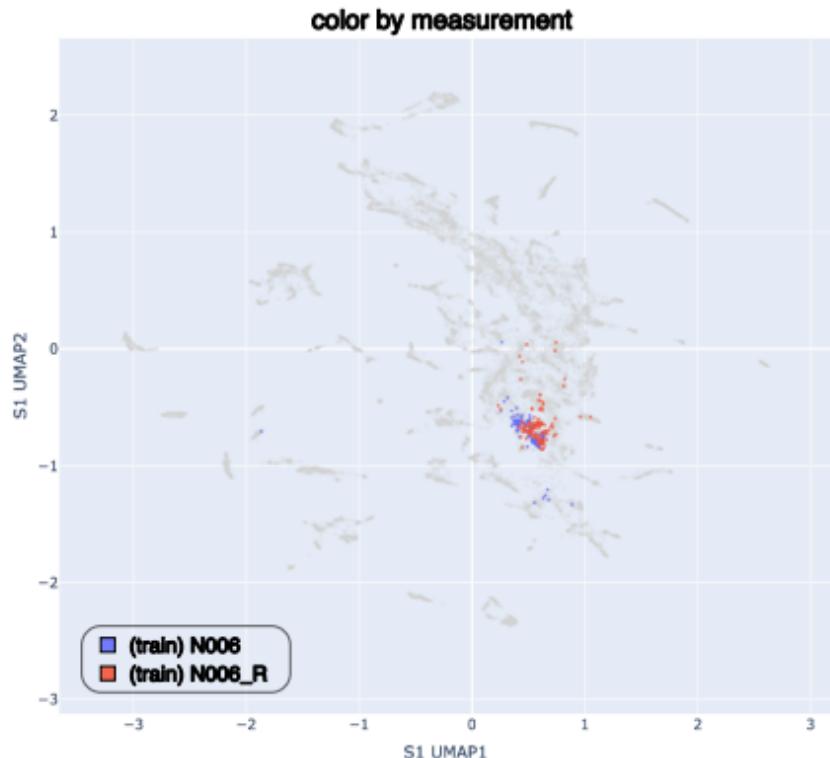
color by subject (new system, train)



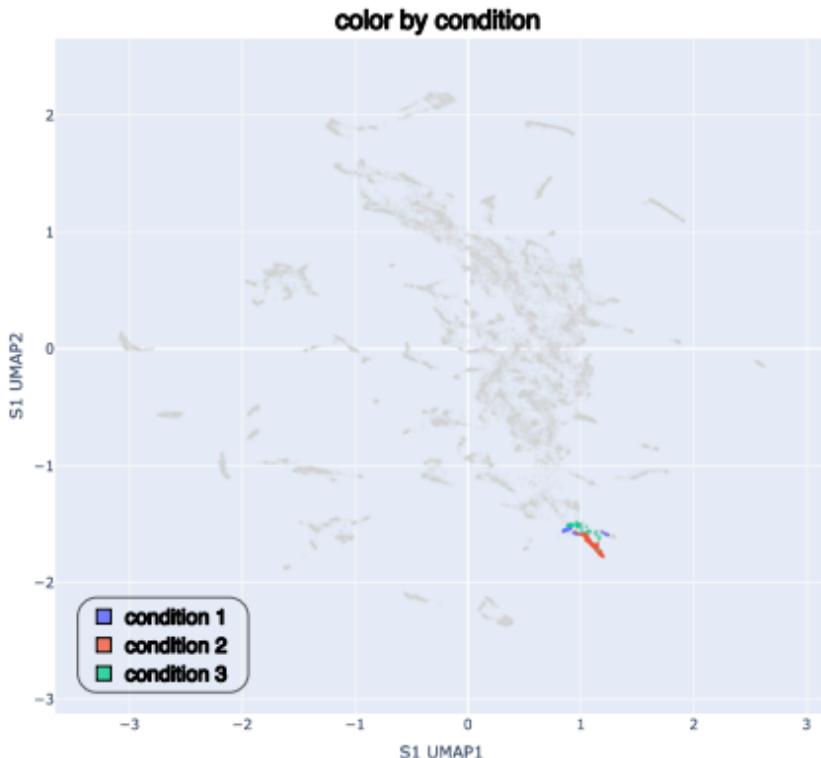
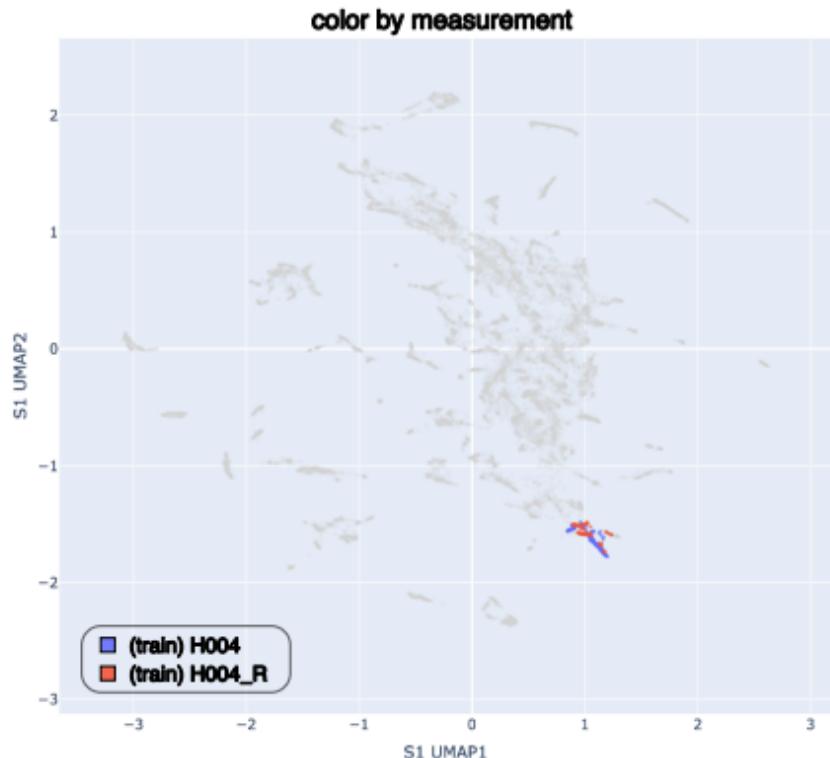
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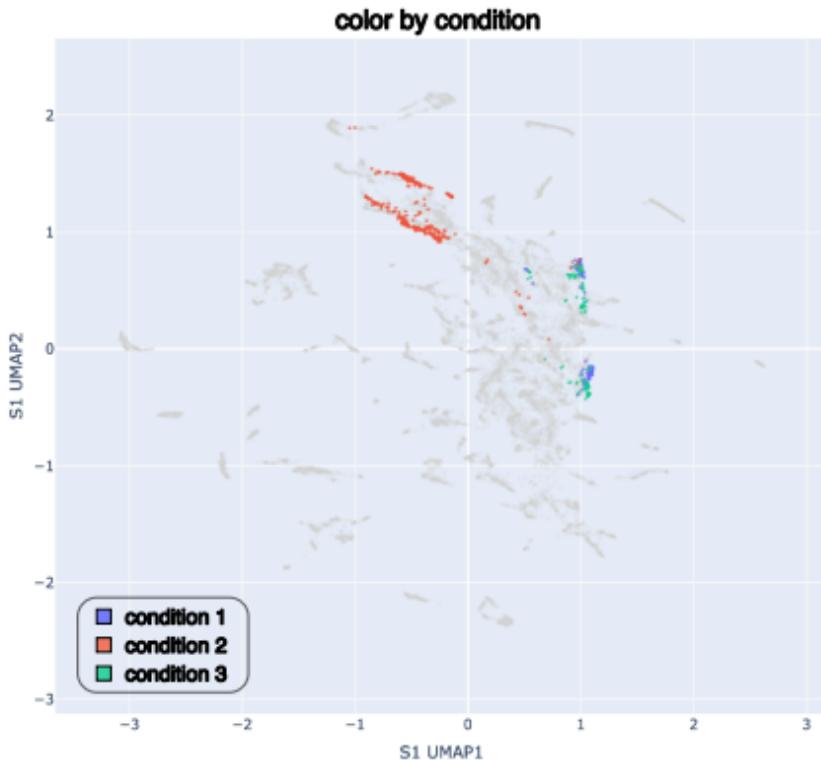
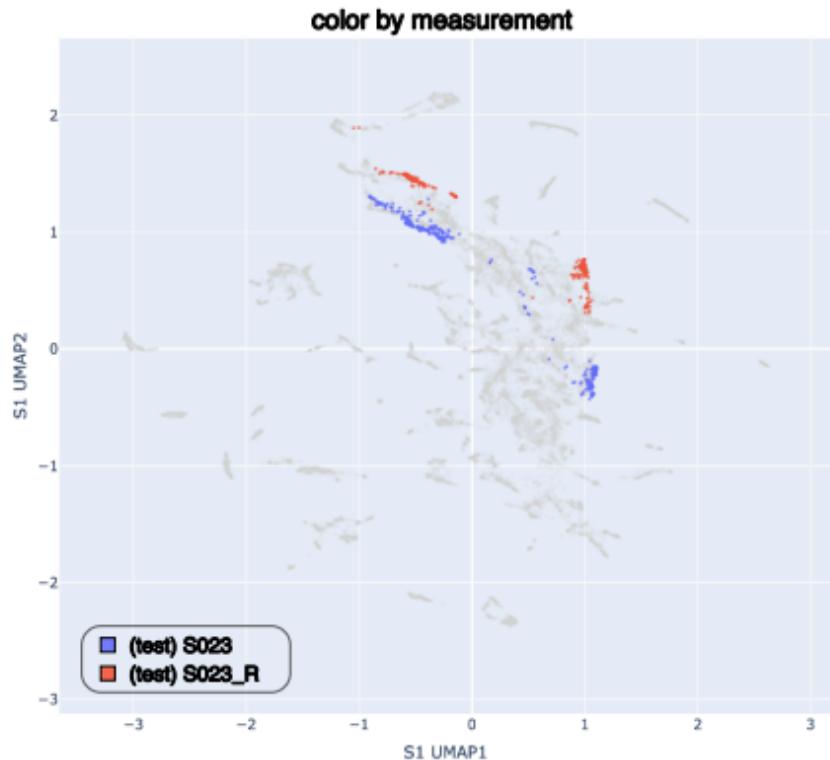
# Result: Stage 1 Samples from same subject and condition cluster together



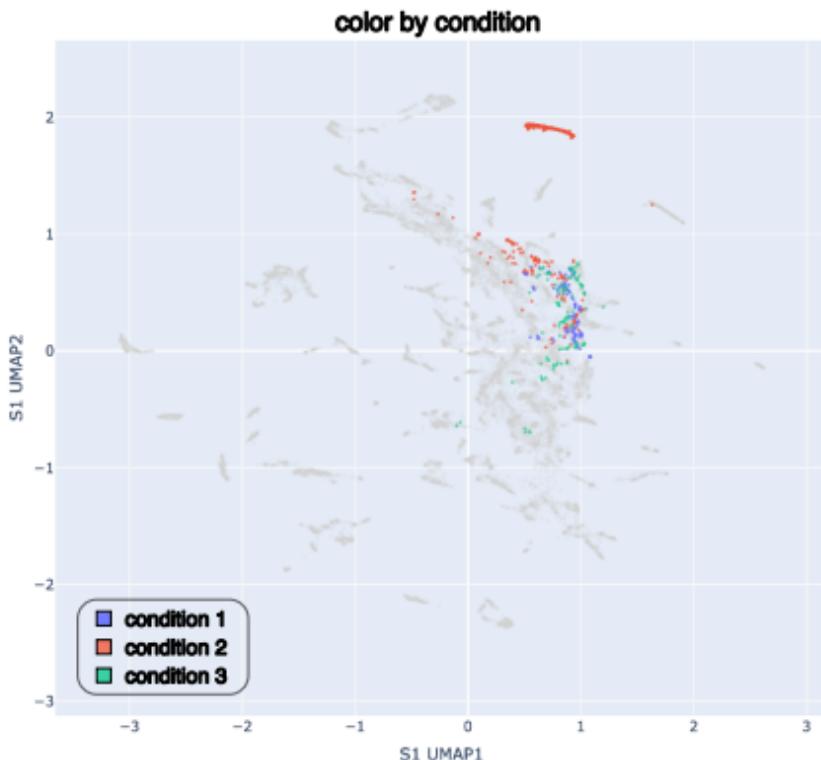
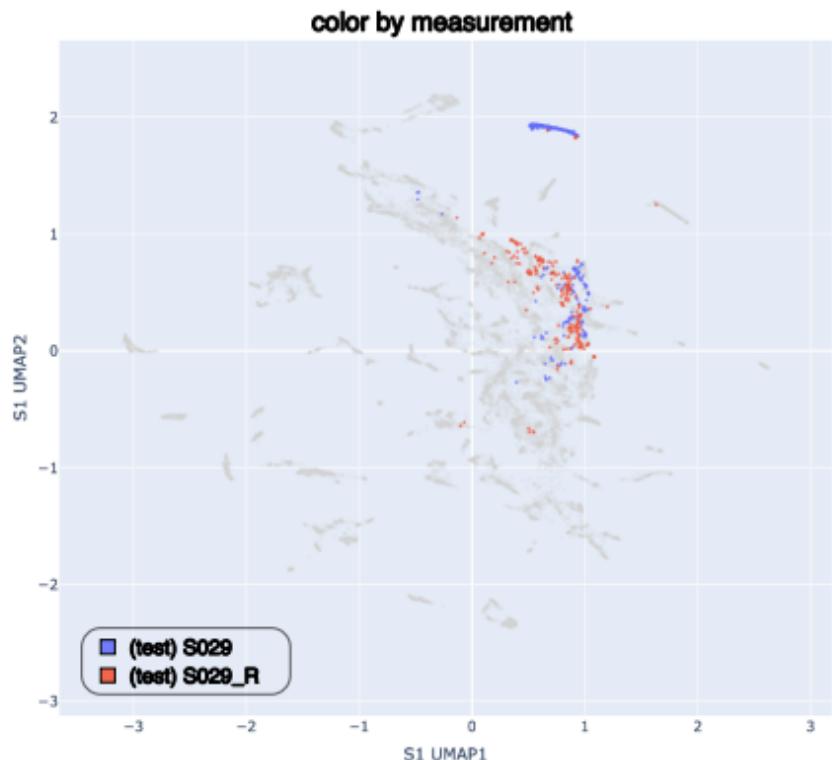
# Result: Stage 1 Samples from same subject and condition cluster together



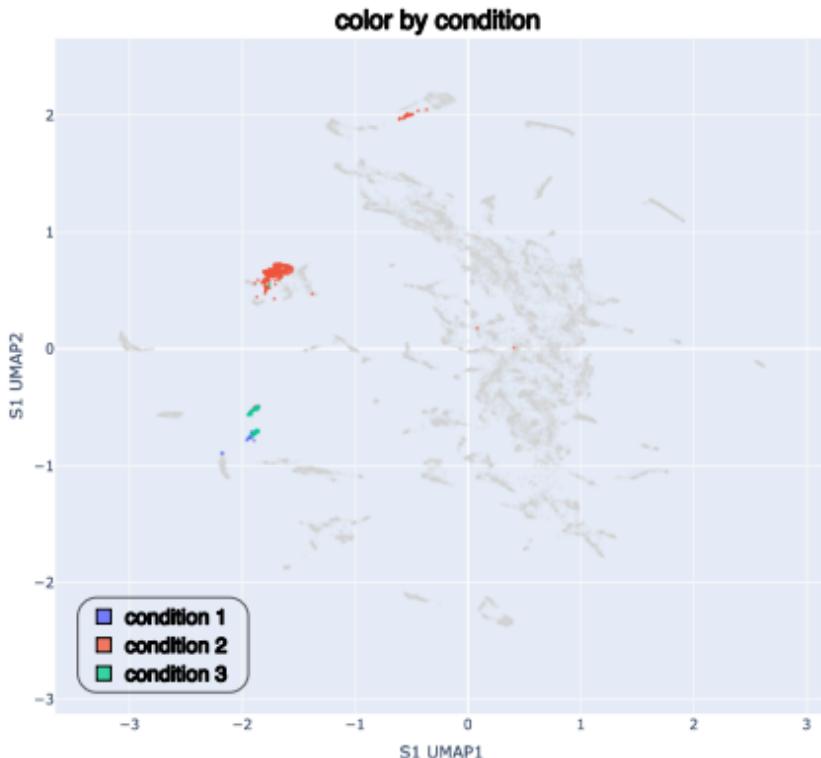
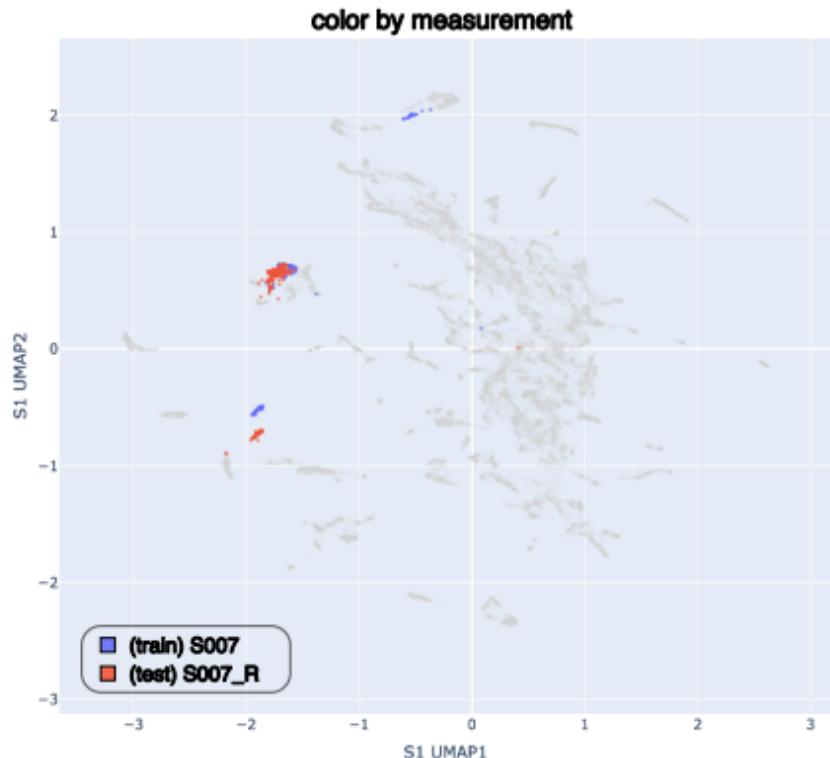
## Result: Stage 1 Samples from same subject and condition cluster together



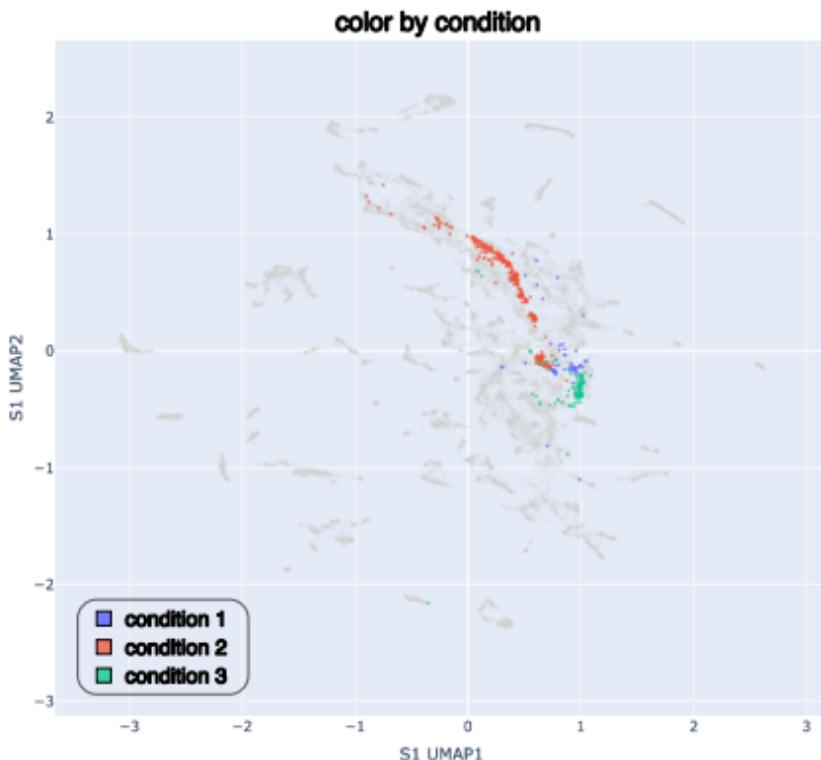
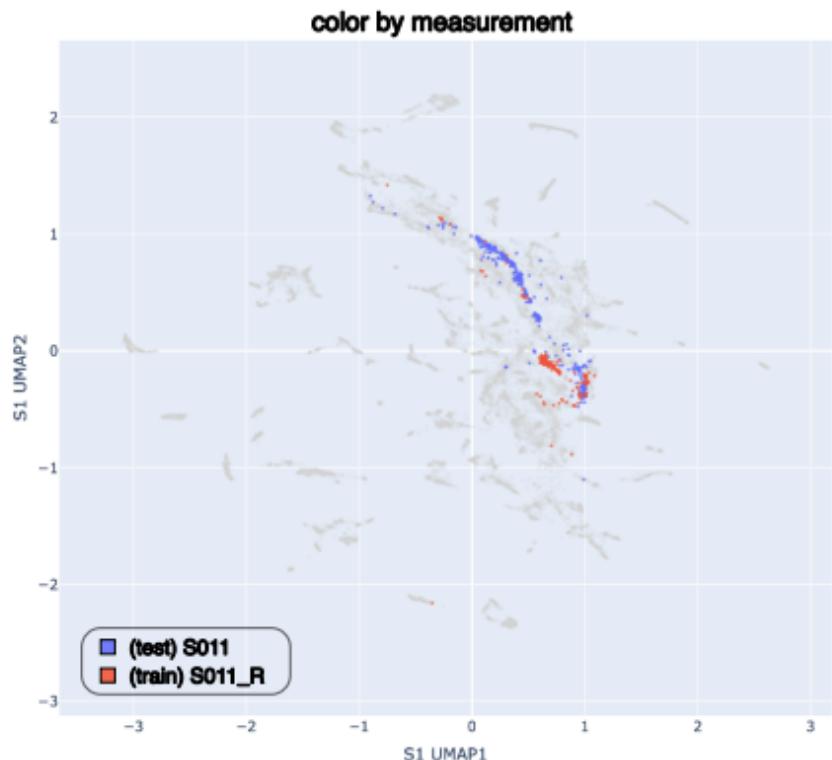
# Result: Stage 1 Samples from same subject and condition cluster together



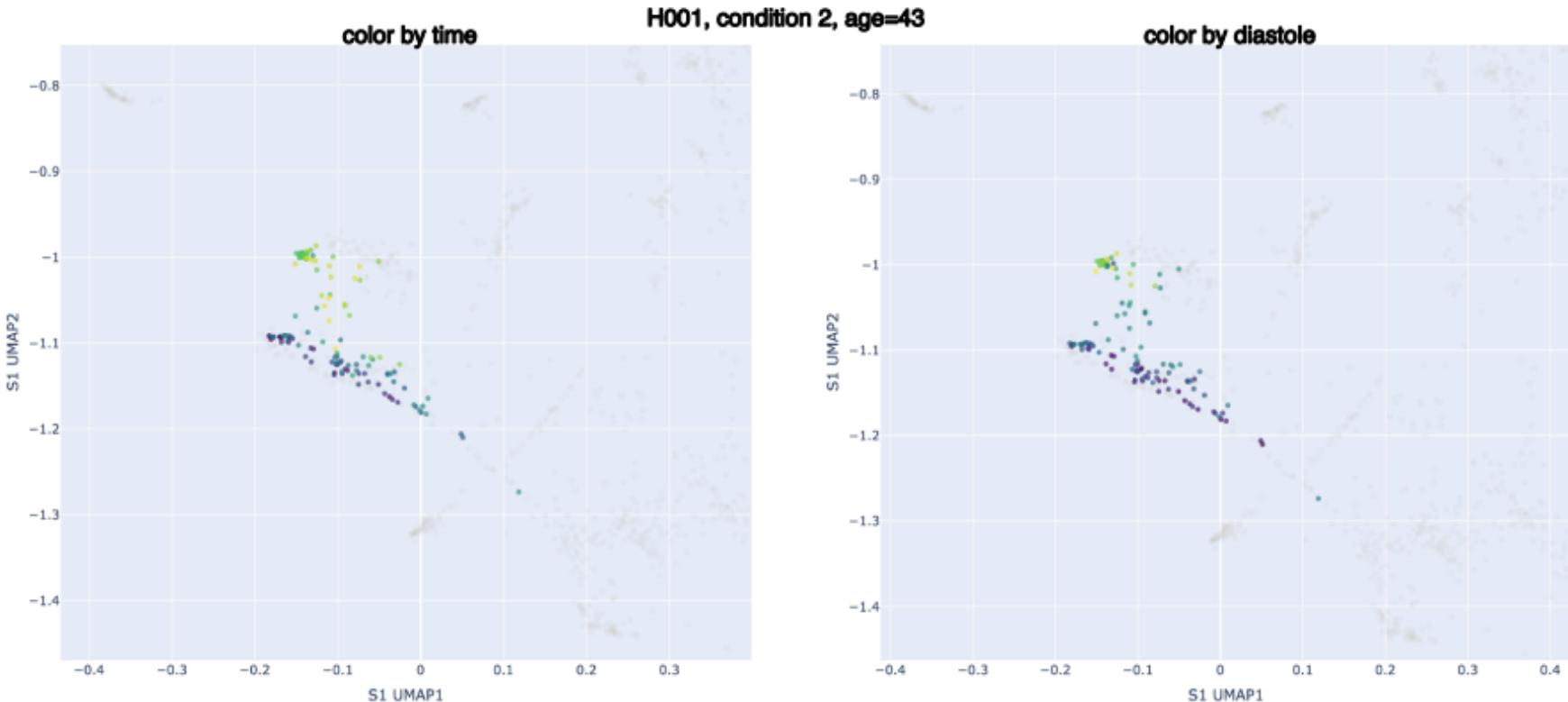
# Result: Stage 1 Samples from same subject and condition cluster together



# Result: Stage 1 Samples from same subject and condition cluster together



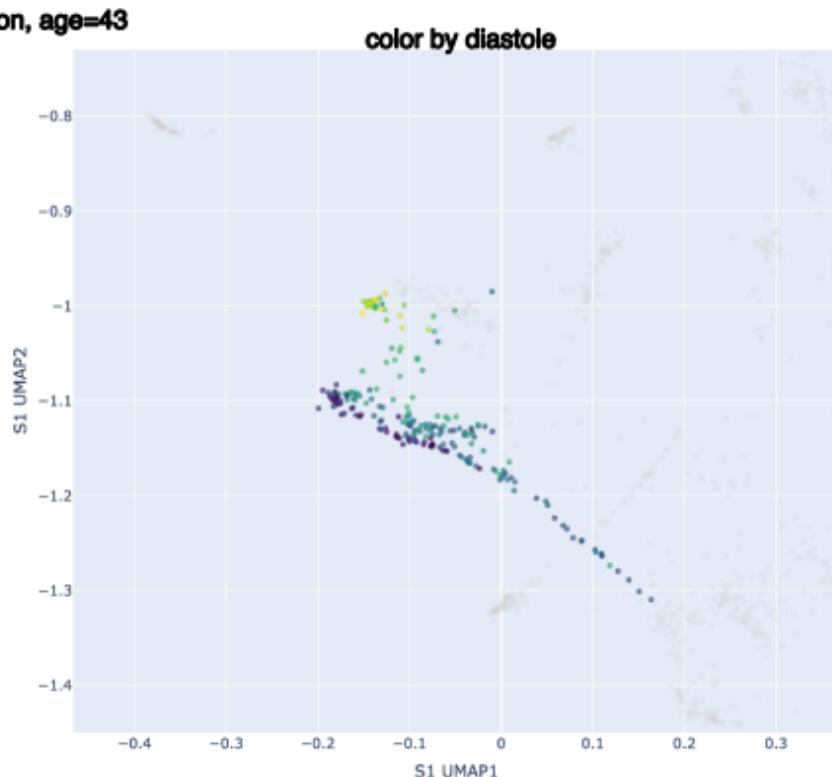
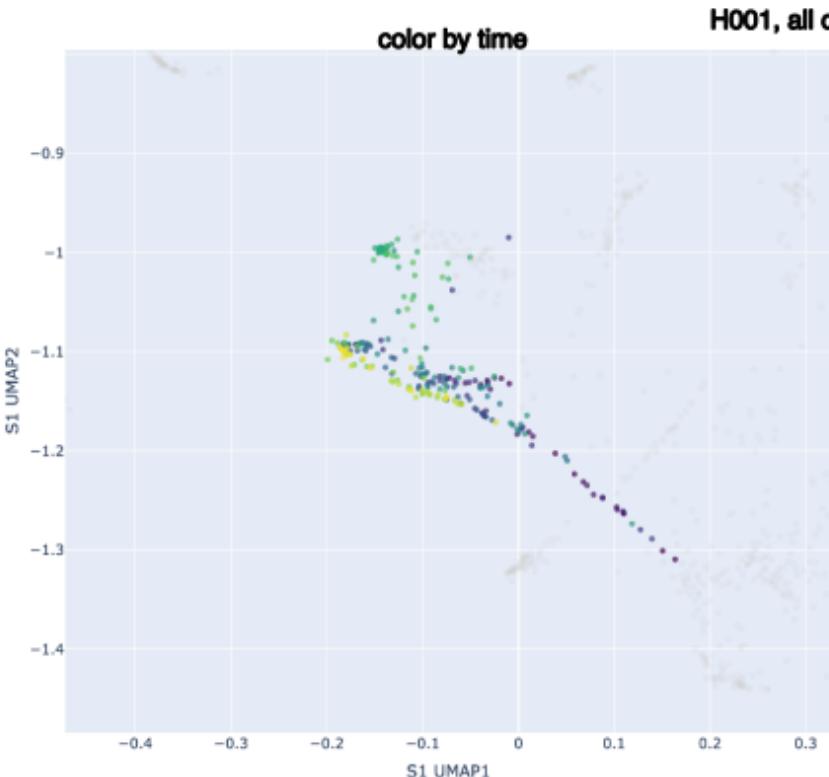
# Result: Stage 1



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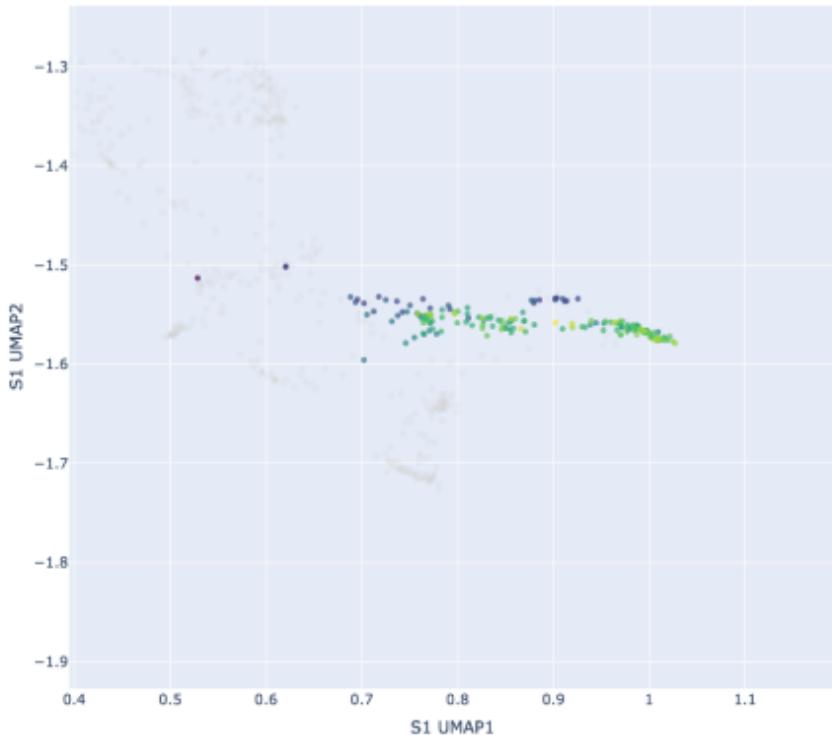
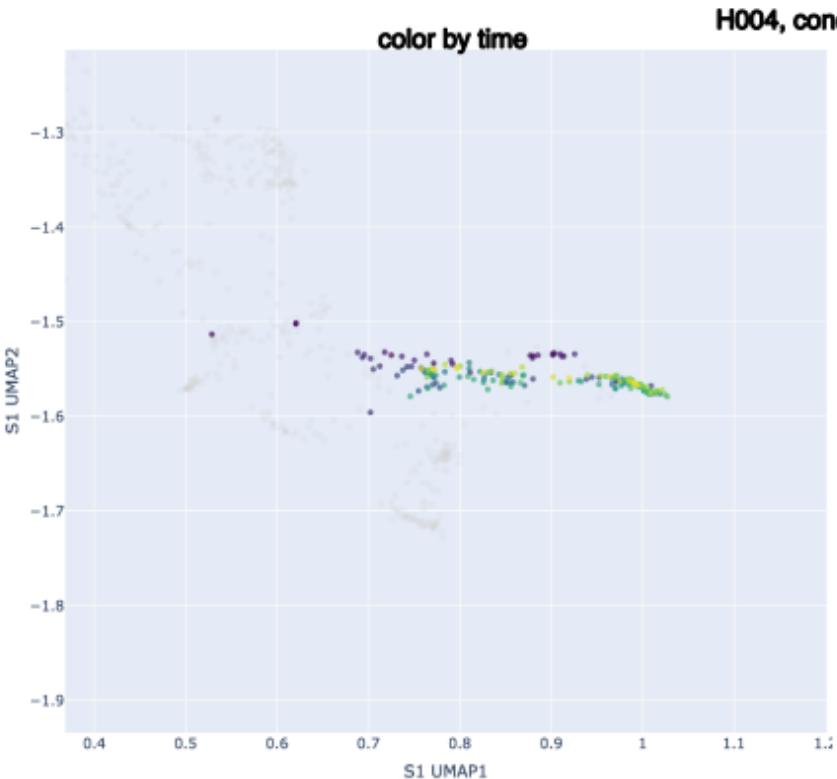
# Result: Stage 1



Biomedical Engineering

Biomedical Optical Technologies Lab

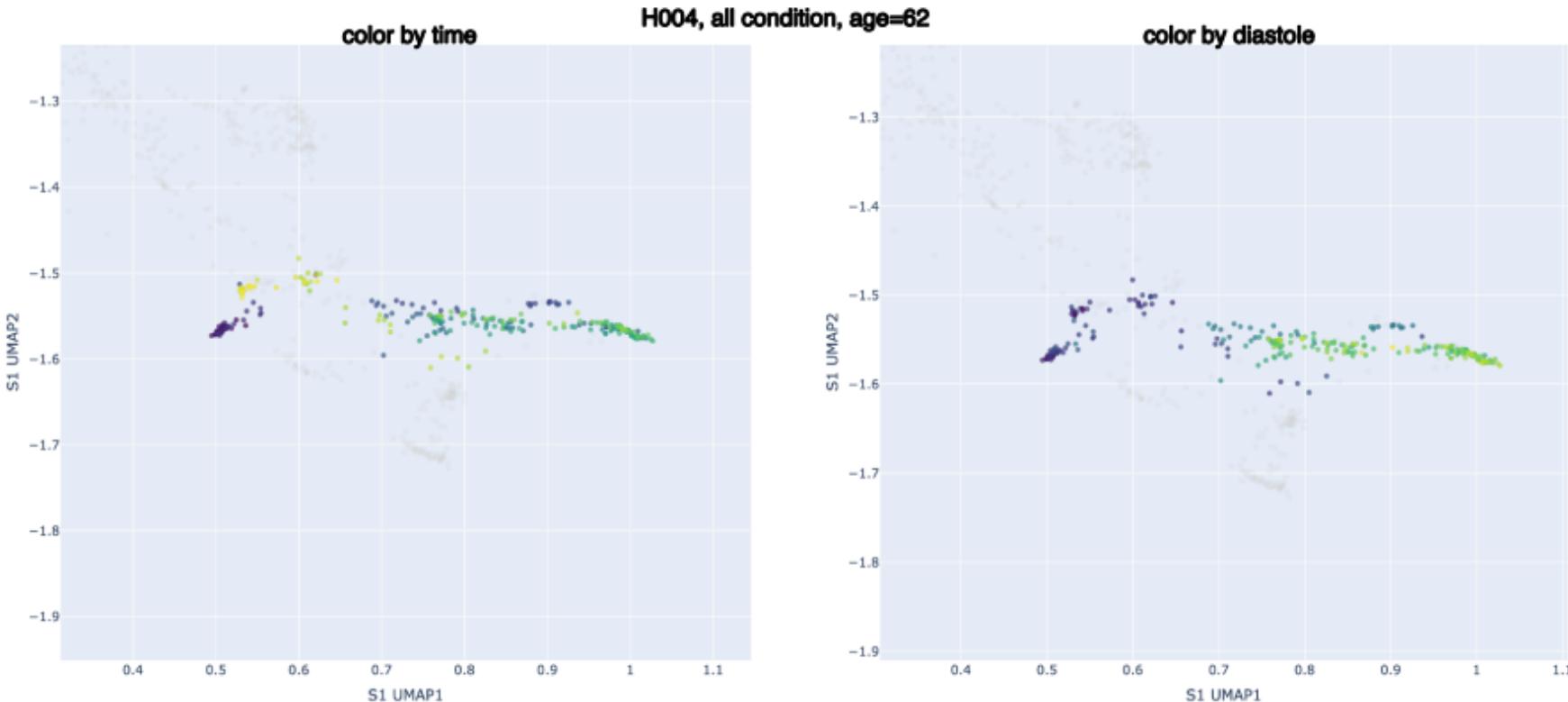
# Result: Stage 1



Biomedical Engineering

Biomedical Optical Technologies Lab

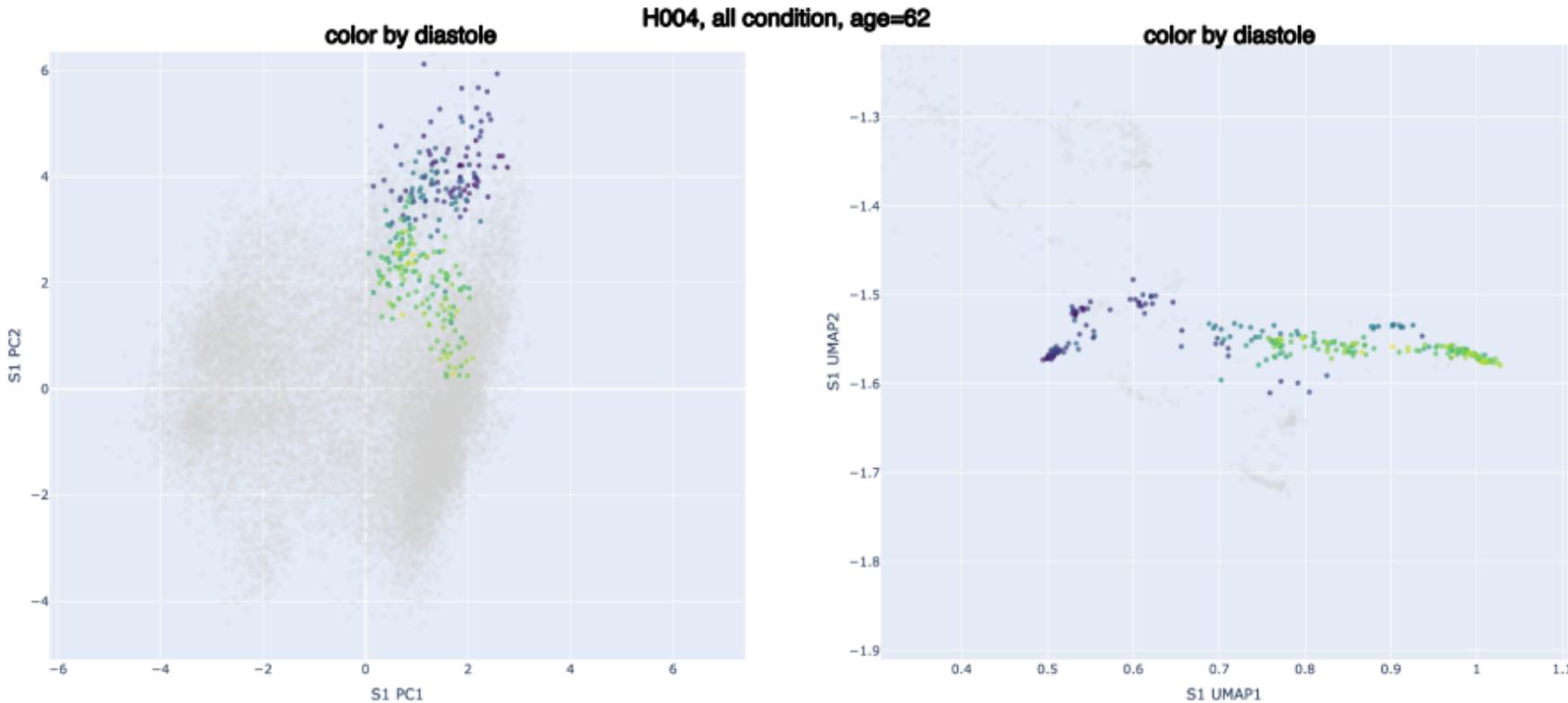
# Result: Stage 1 Smple with similar BP from different condition group together



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Biomedical Optical Technologies Lab

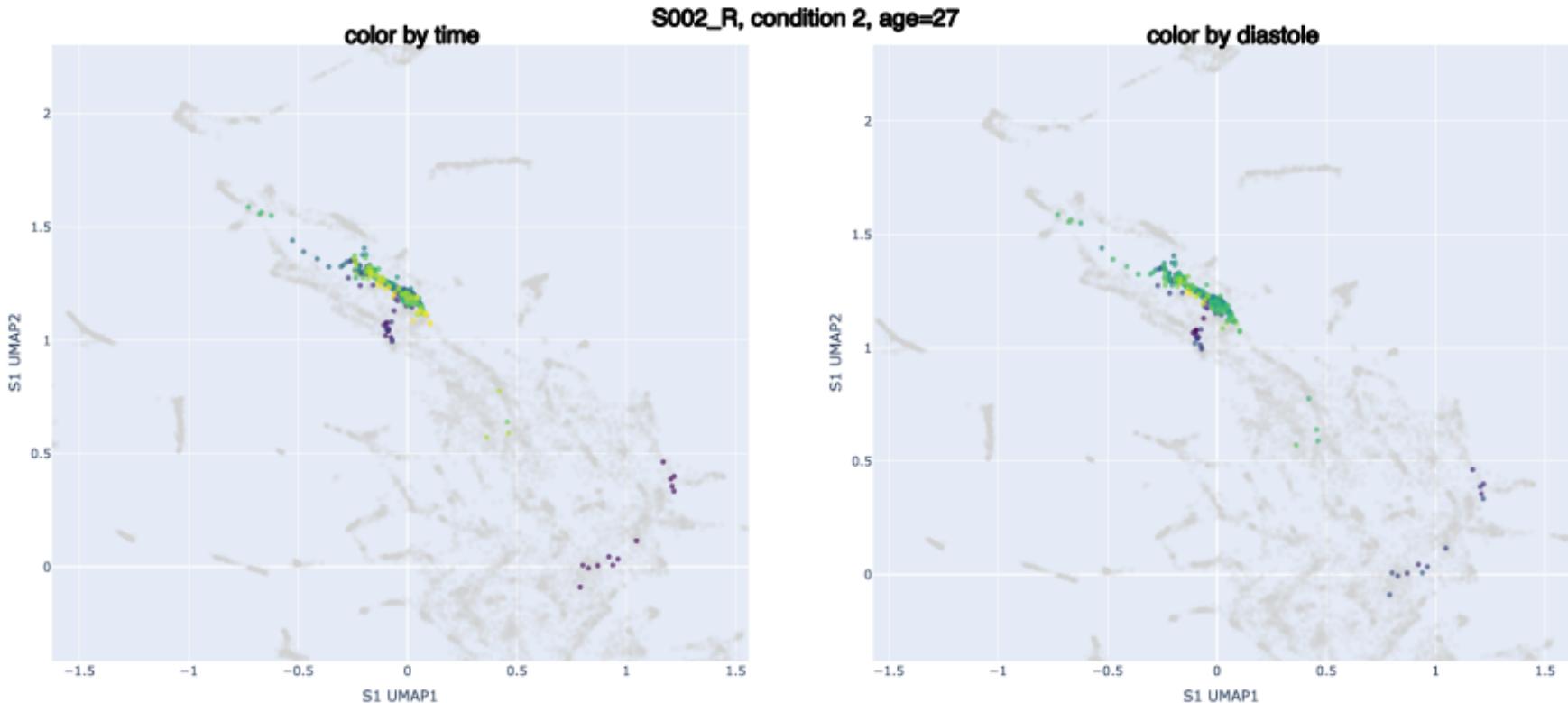
# Result: Stage 1



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Biomedical Optical Technologies Lab

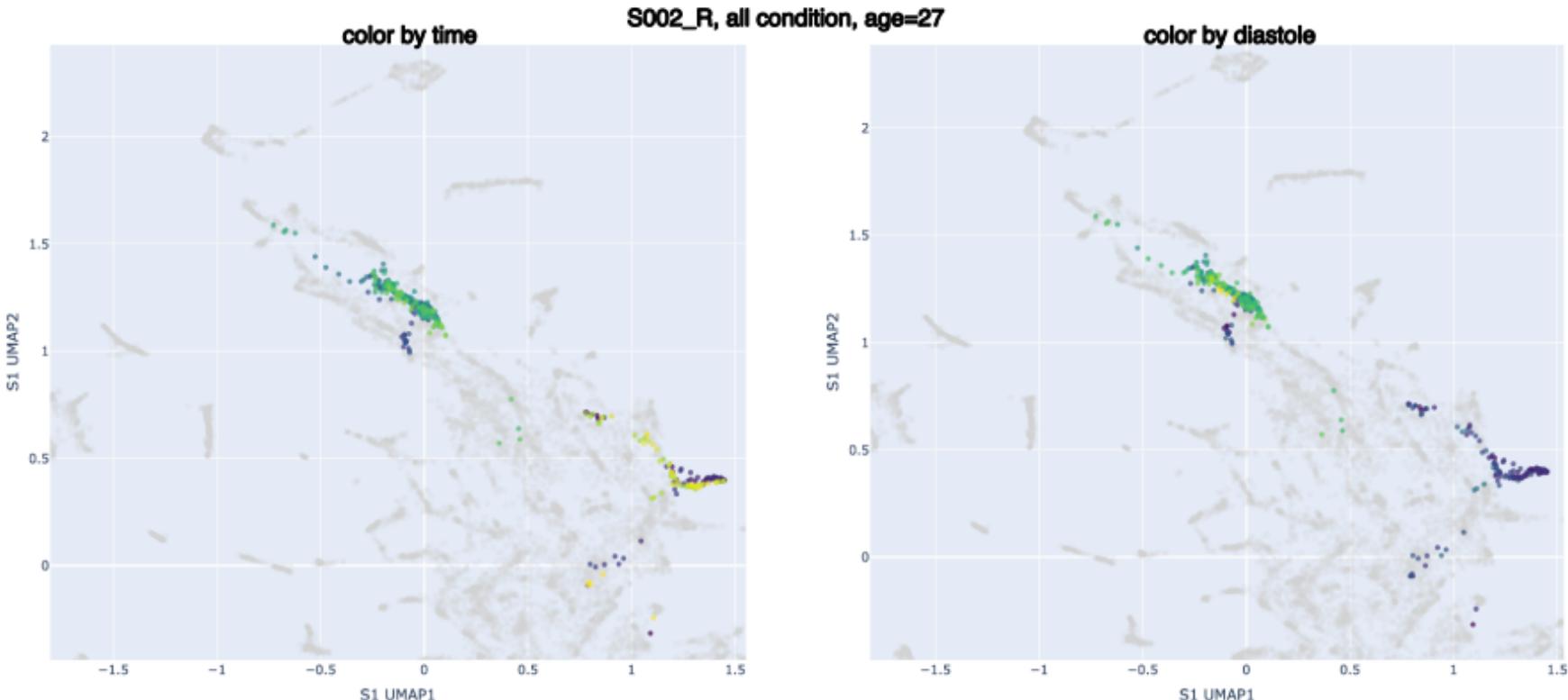
# Result: Stage 1



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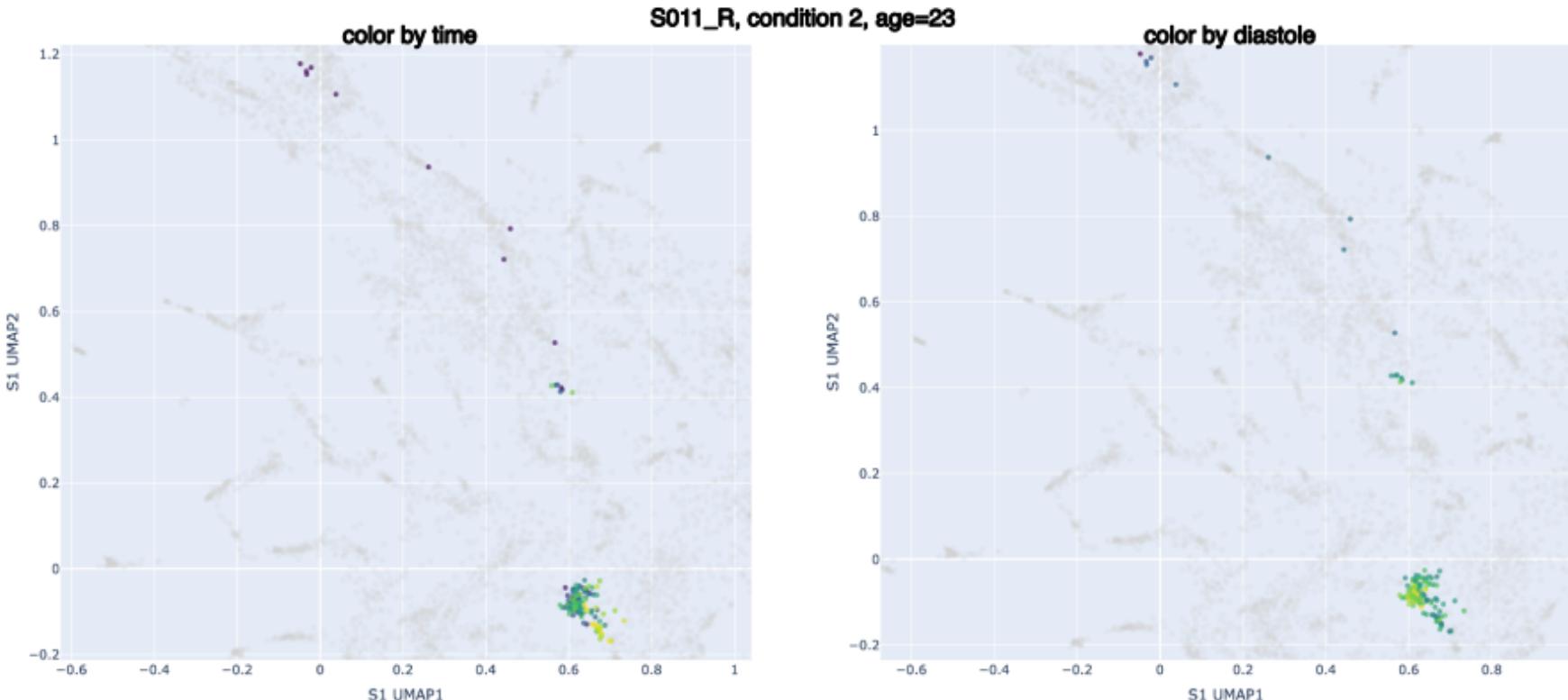
# Result: Stage 1 Smple with similar BP from different condition group together



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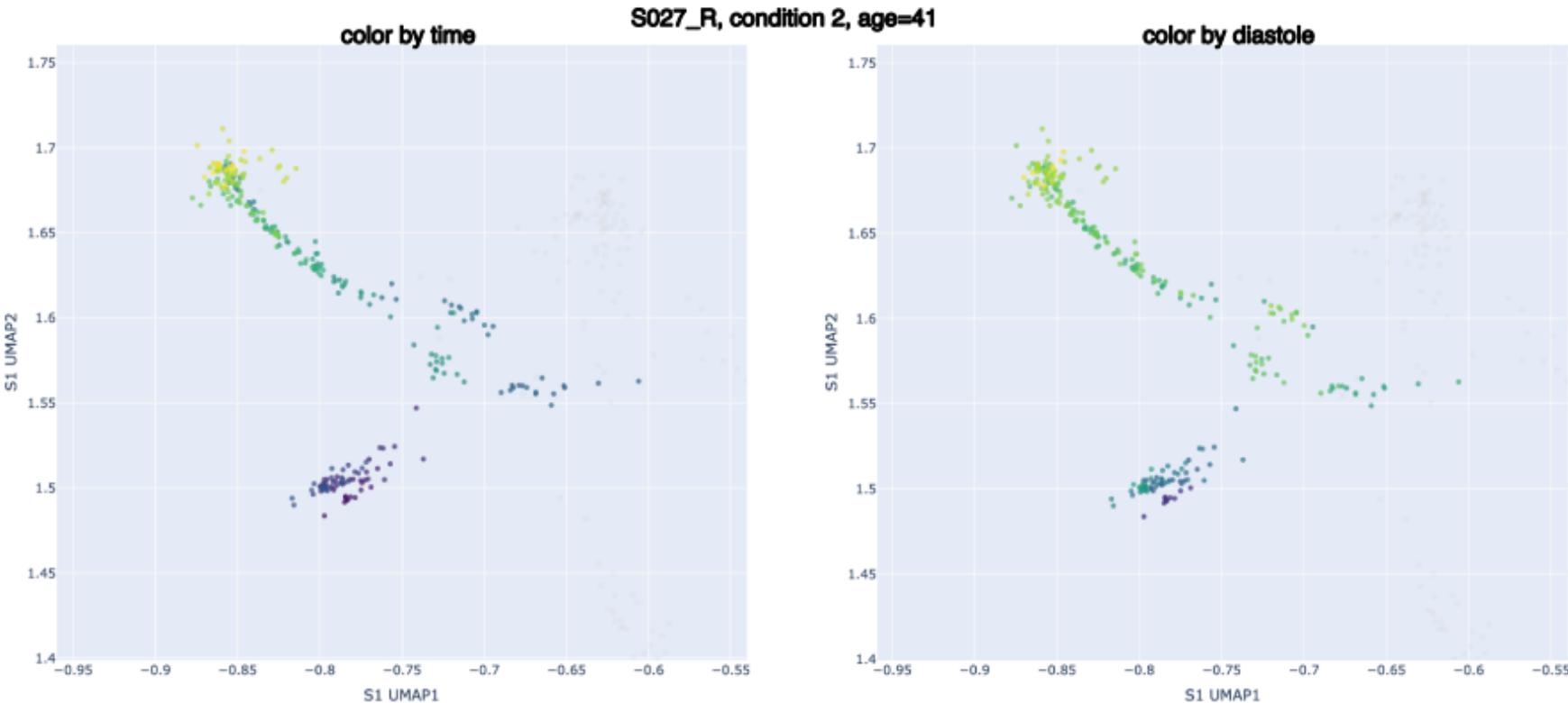
# Result: Stage 1



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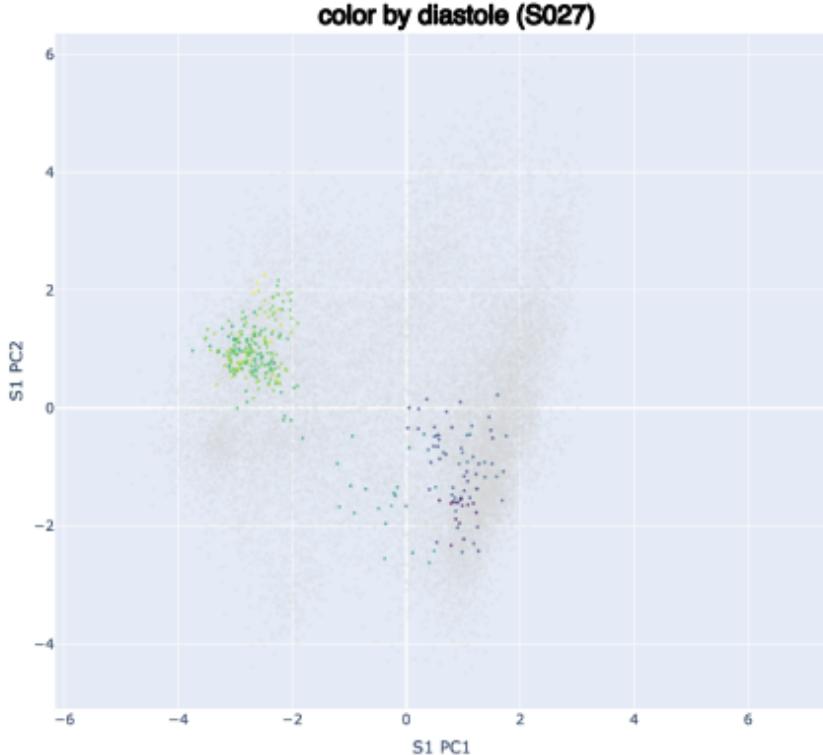
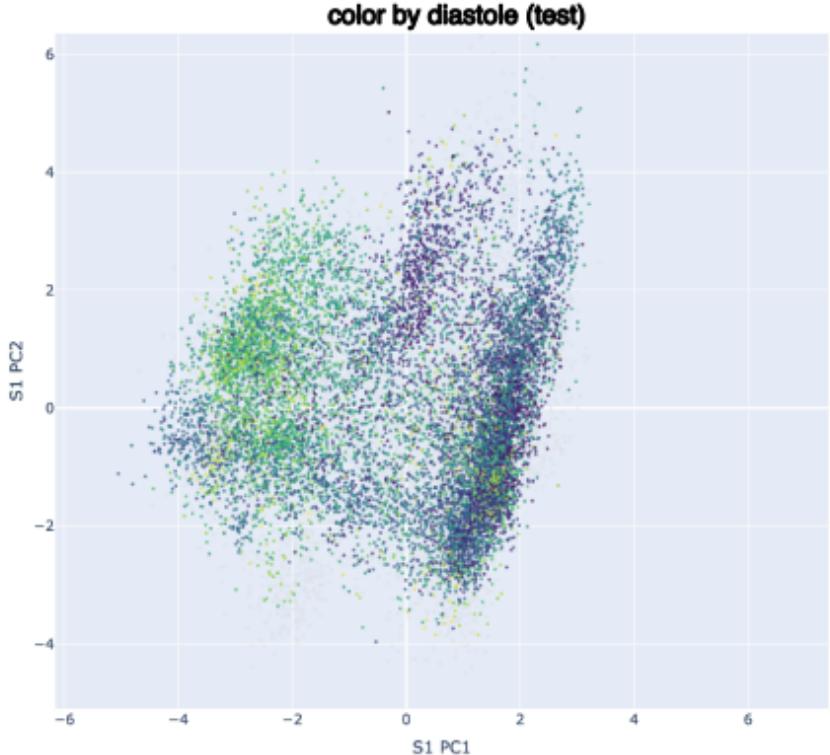
# Result: Stage 1



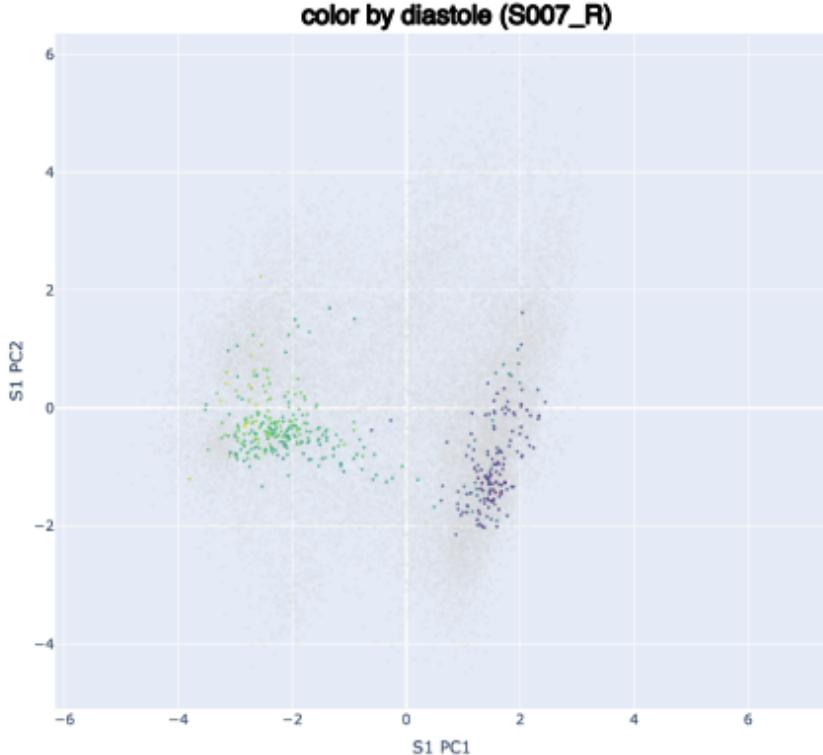
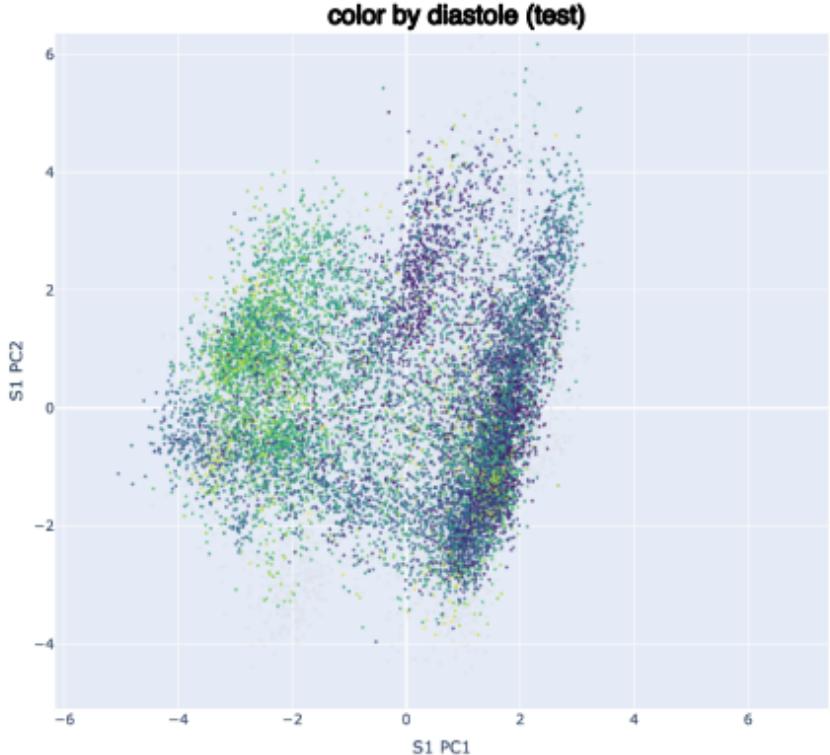
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# Result: Stage 1 First two PC exhibit trend relate to blood pressure



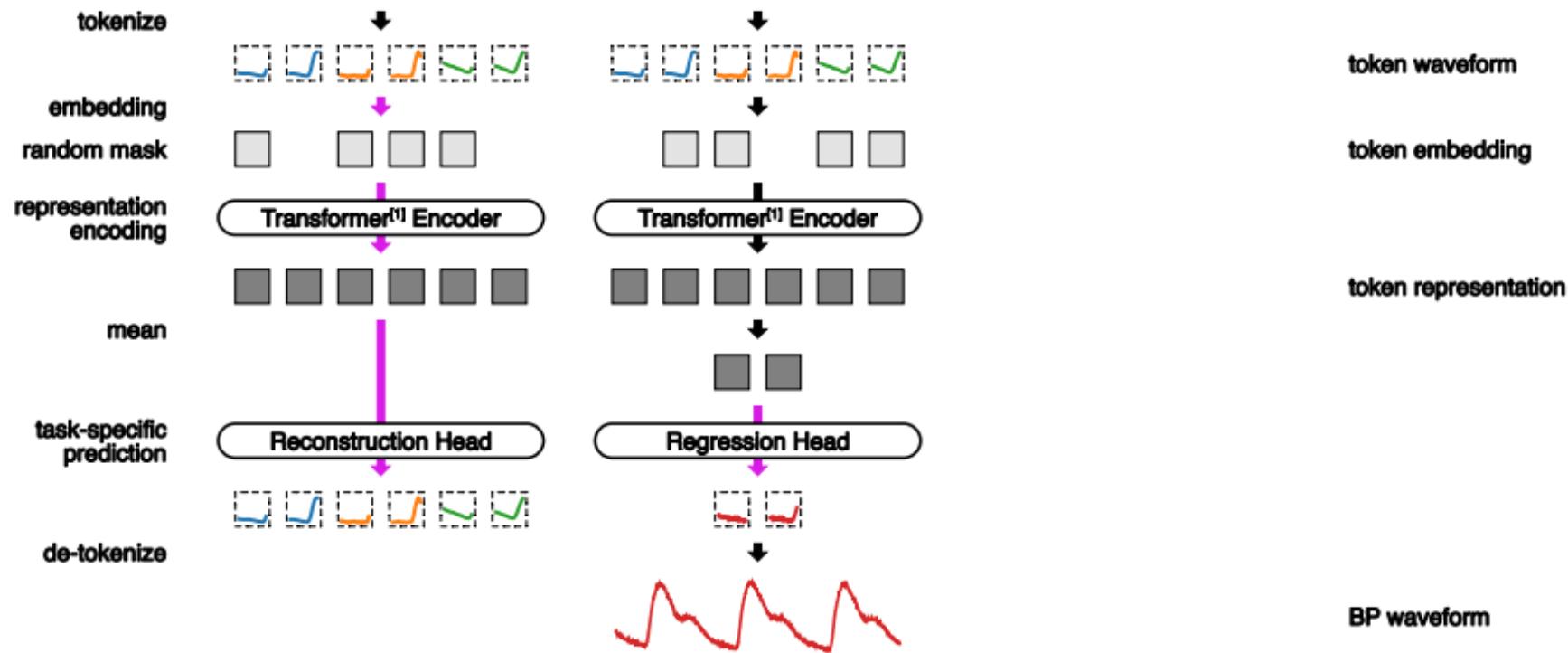
# Result: Stage 1 First two PC exhibit trend relate to blood pressure



# Model: Stage 2

[1] Vaswani, A. et al. Attention Is All You Need. arXiv:1706.03762 (2017).

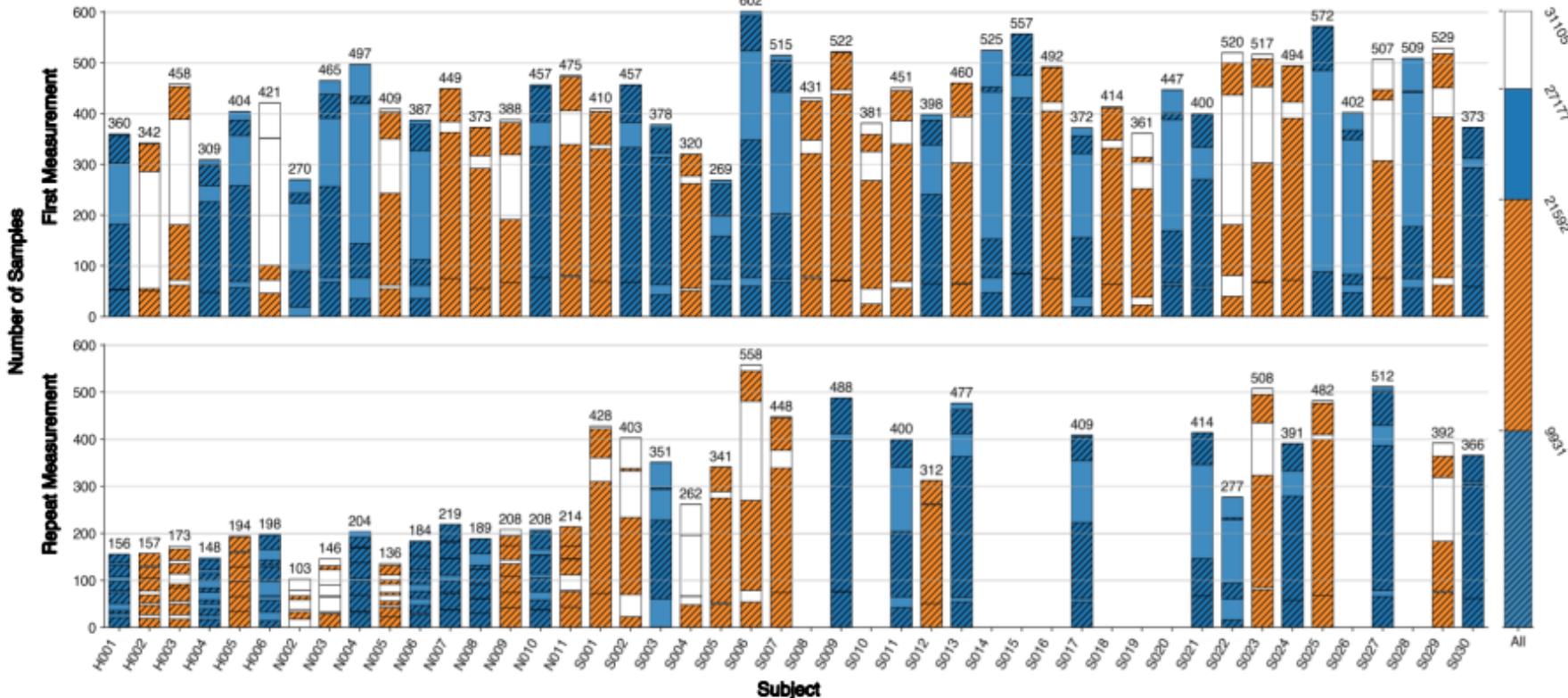
↑ trainable → fixed



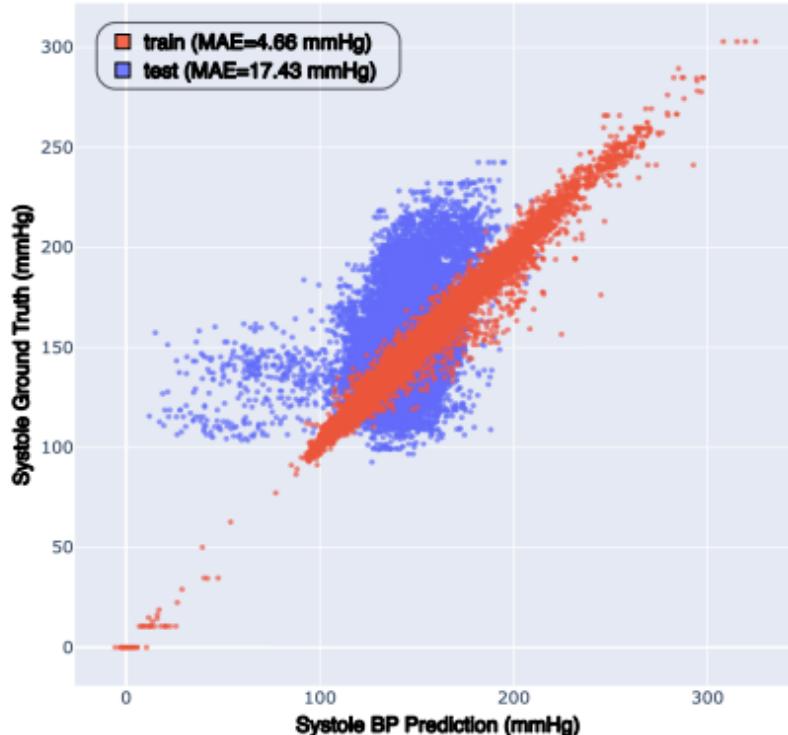
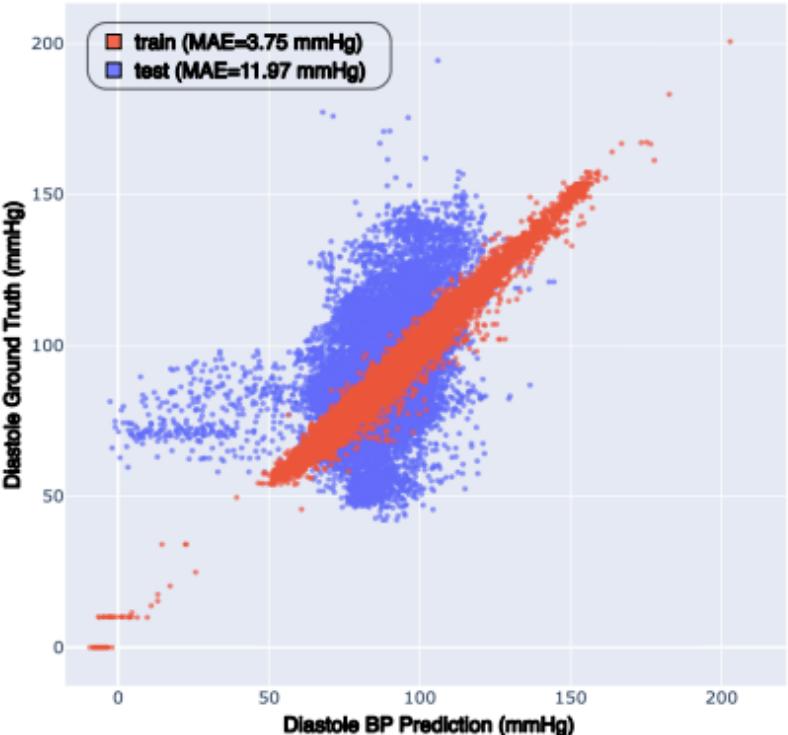
# Data: Stage 2 Split

Wang, Y. et al. How to evaluate your medical time series classification? arXiv 2410.03057 (2024).

split  
train test



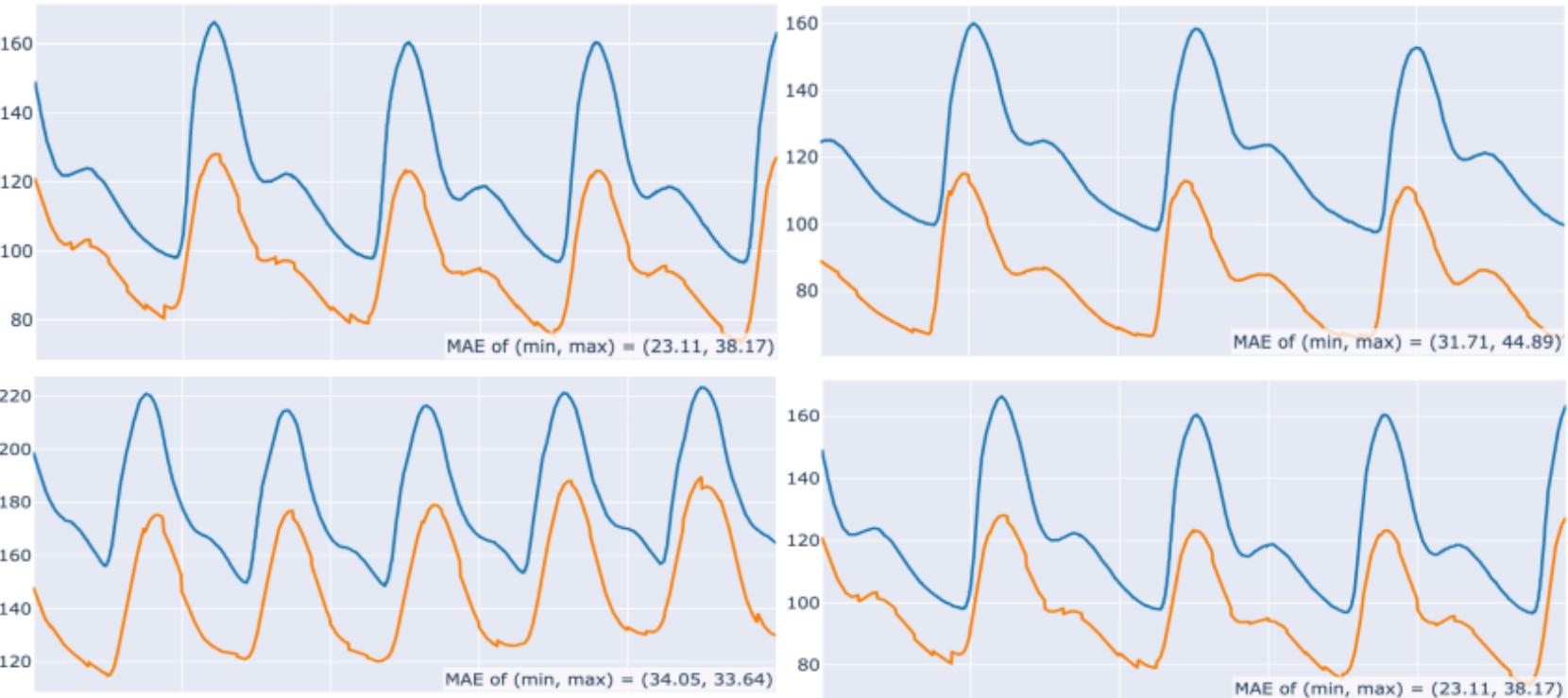
## Result: Stage 2 Systolic and diastolic prediction does not generalize to test set



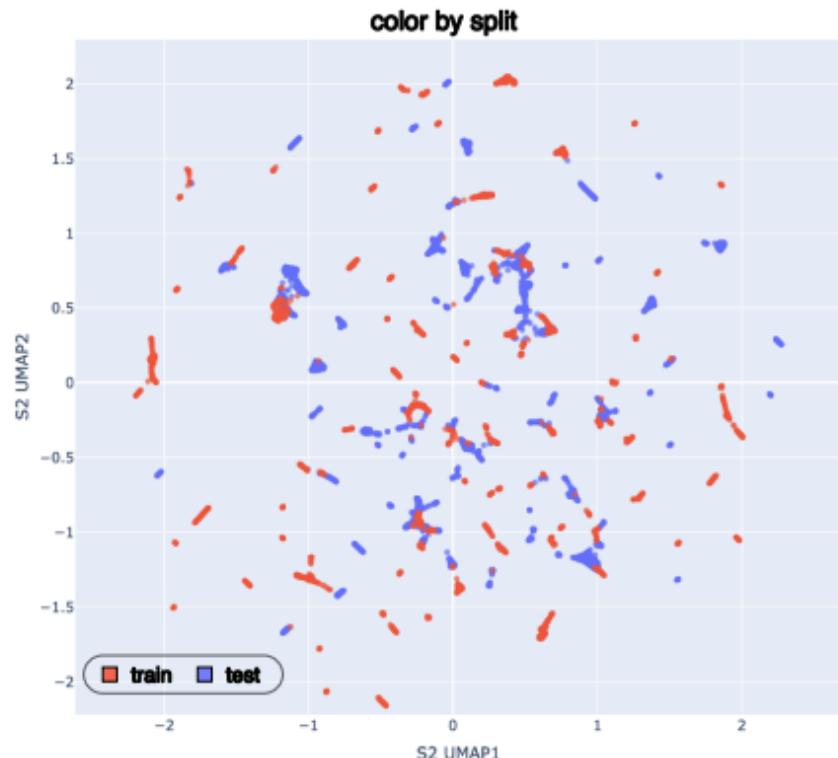
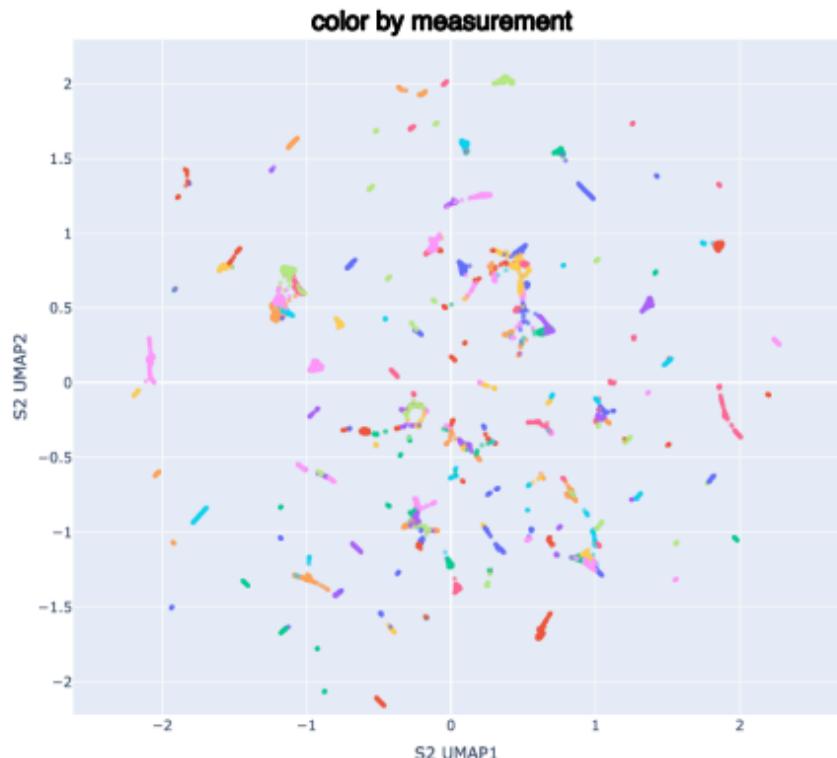
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## Result: Stage 2 Model captures wave shape, but absolute BP values are shifted



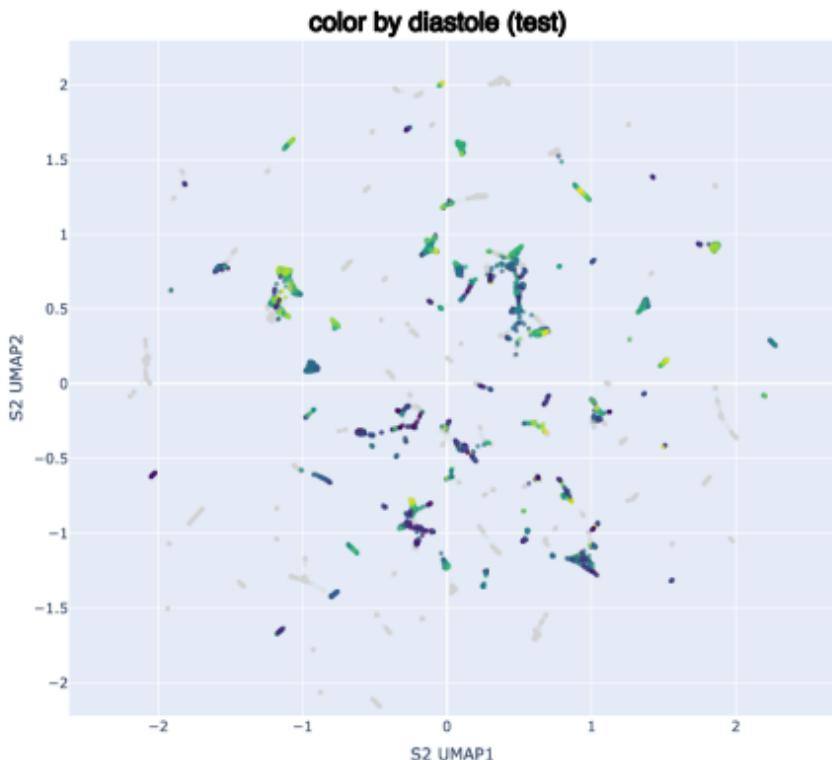
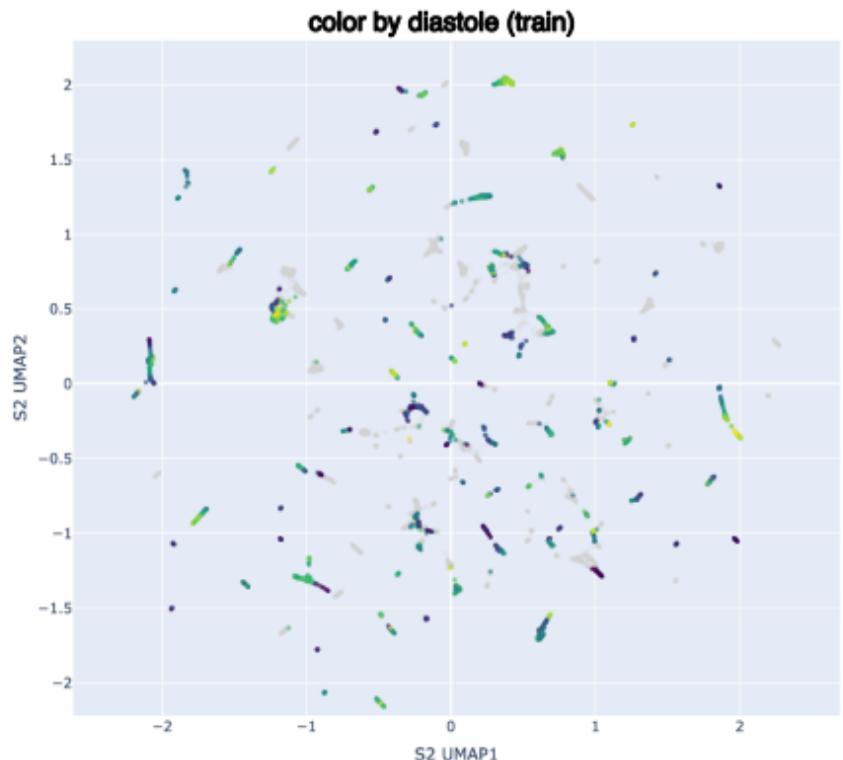
## Result: Stage 2 Representations become more subject-specific



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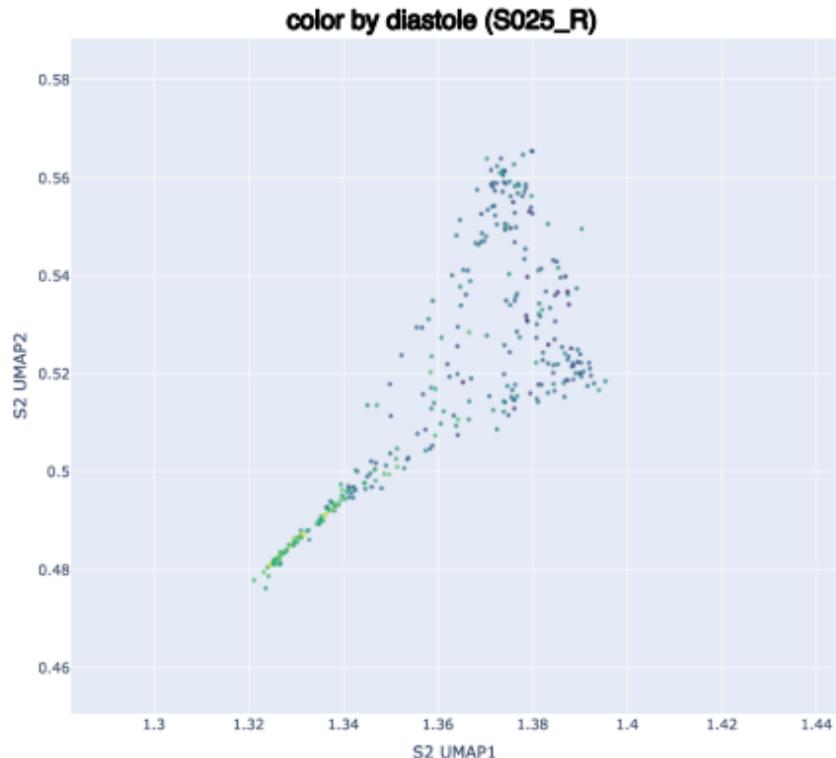
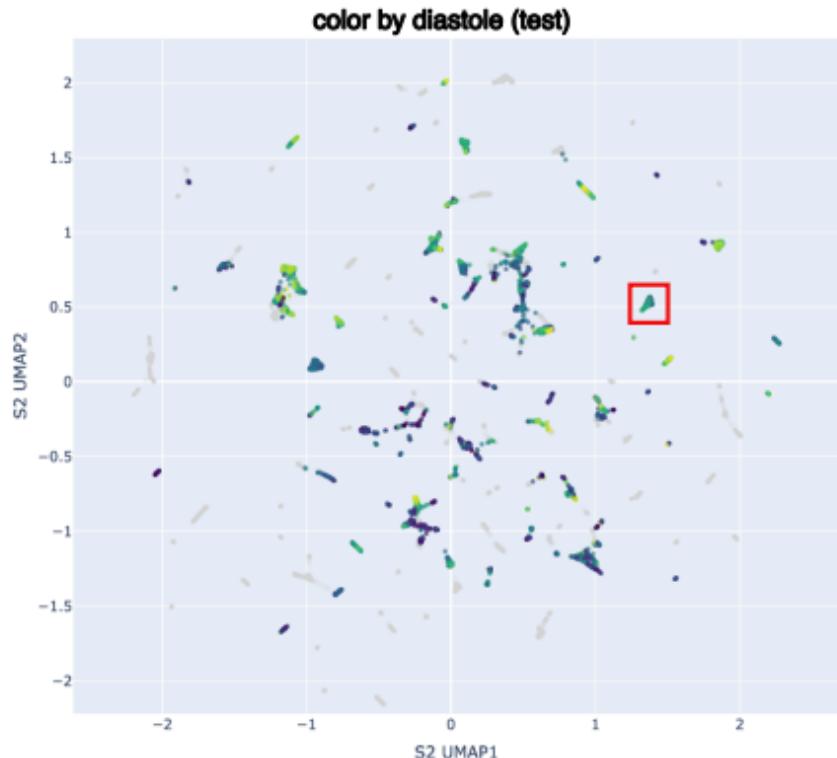
## Result: Stage 2 Representation follows BP variation



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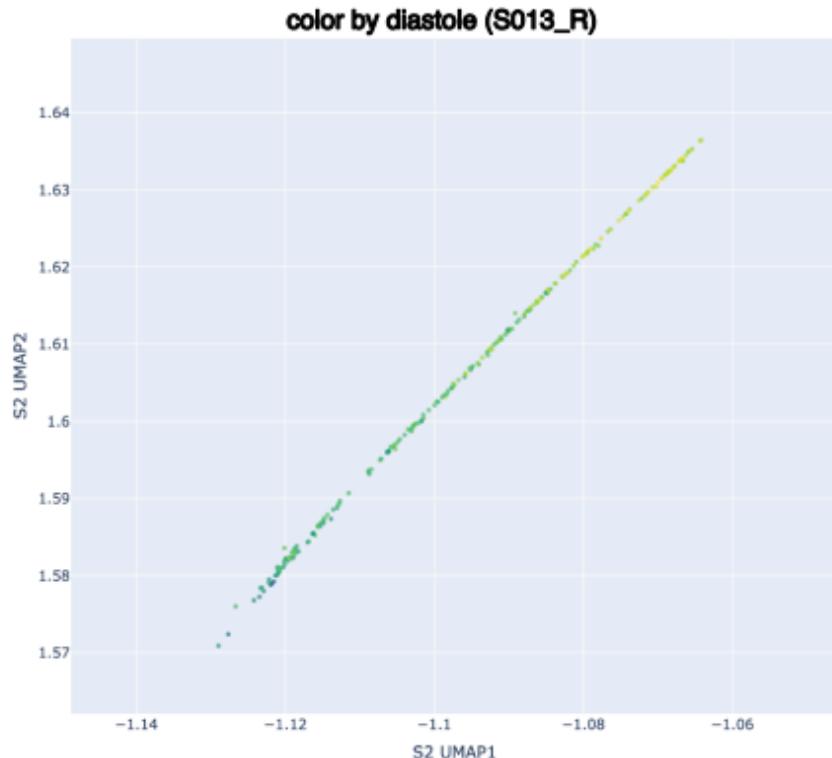
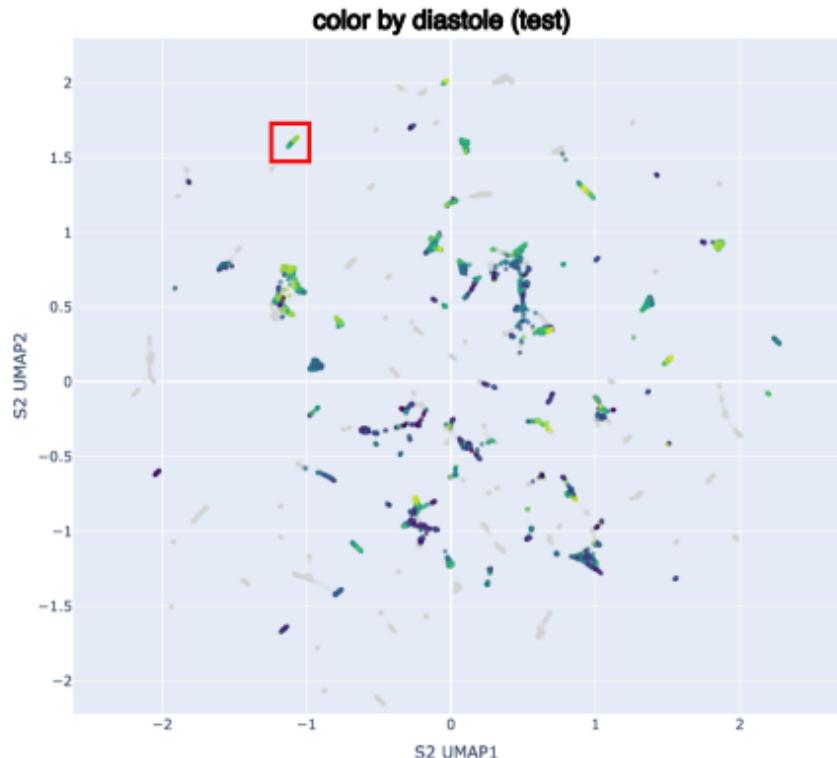
## Result: Stage 2 Representations become more subject-specific



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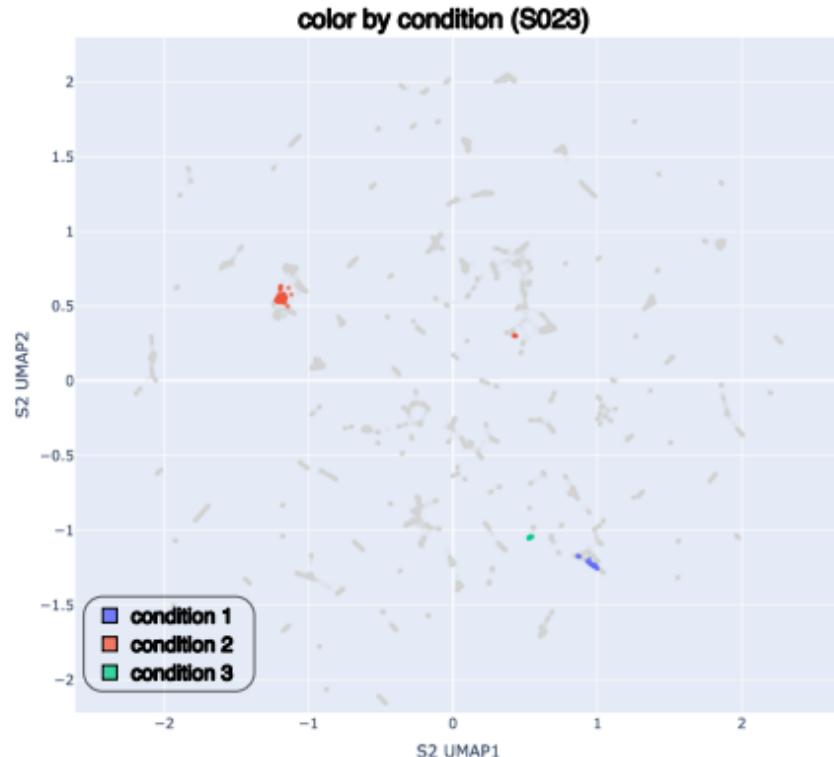
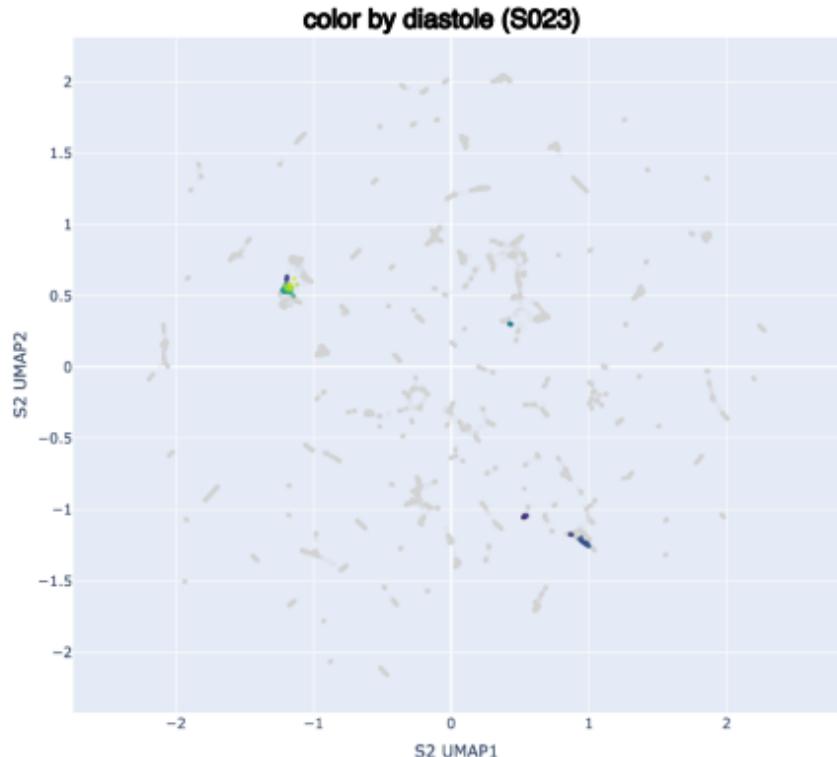
## Result: Stage 2 Representations become more subject-specific



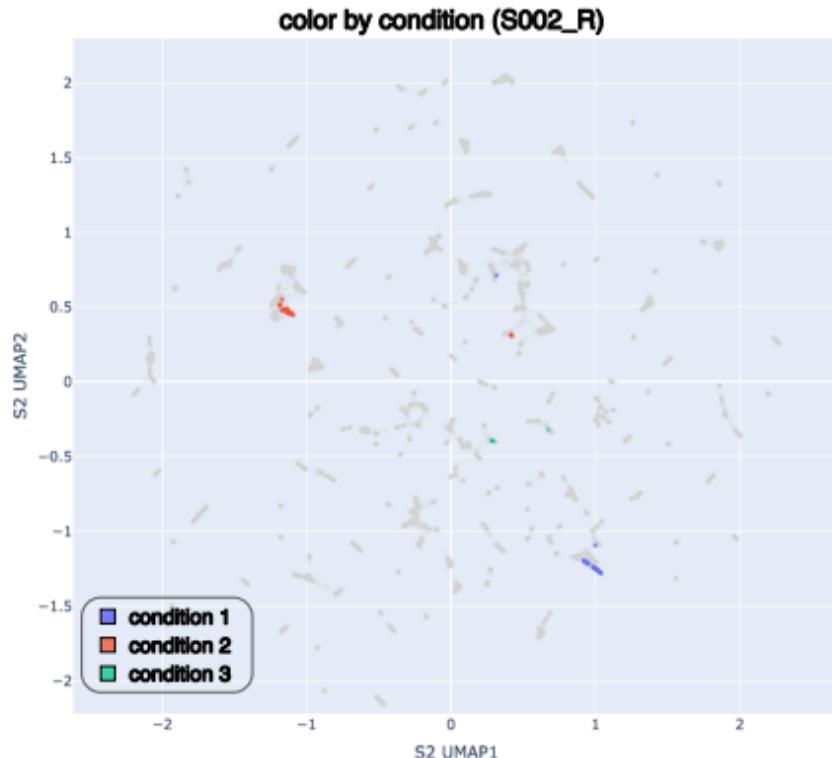
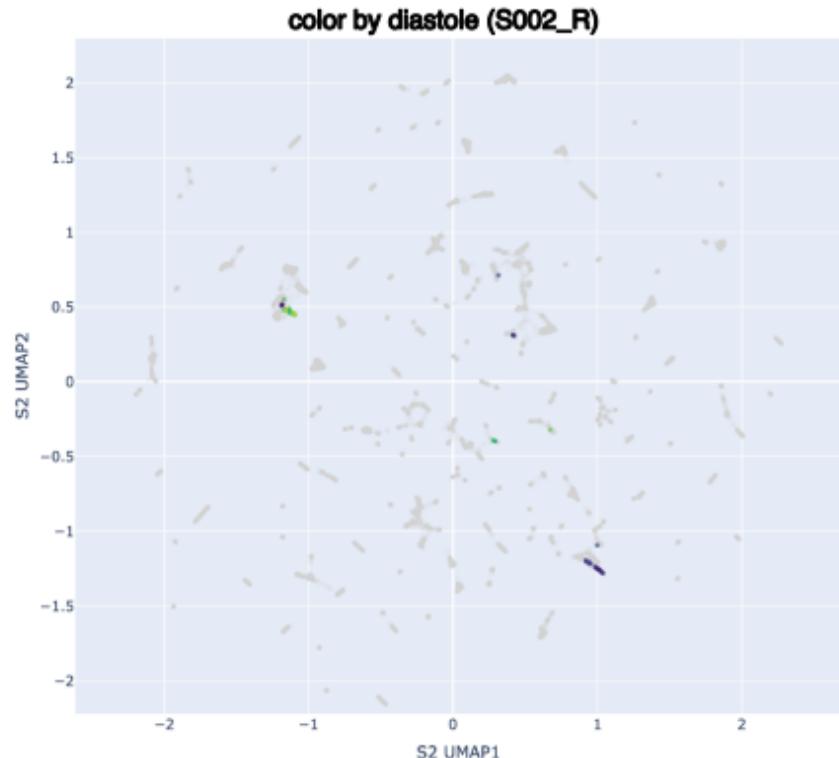
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## Result: Stage 2   Different condition within a measurement no longer group together



## Result: Stage 2   Different condition within a measurement no longer group together



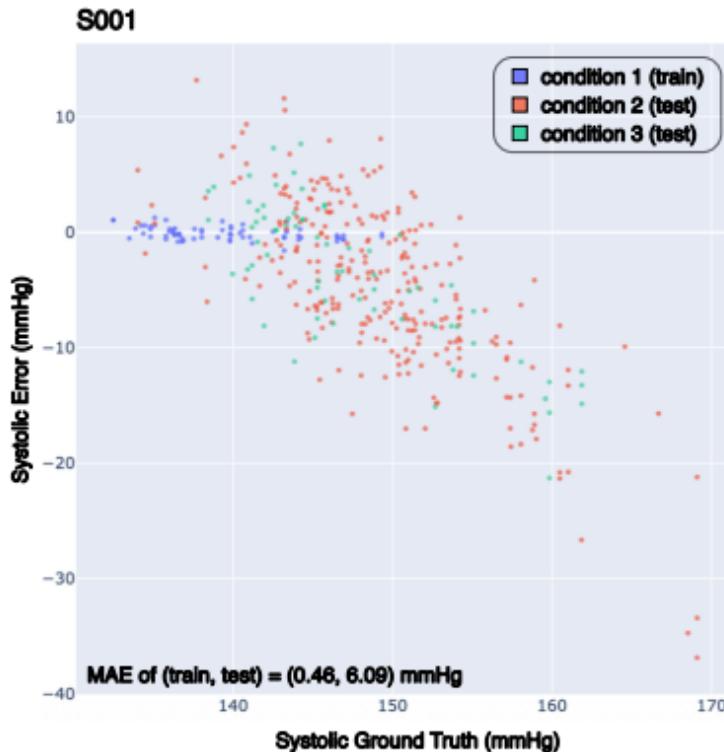
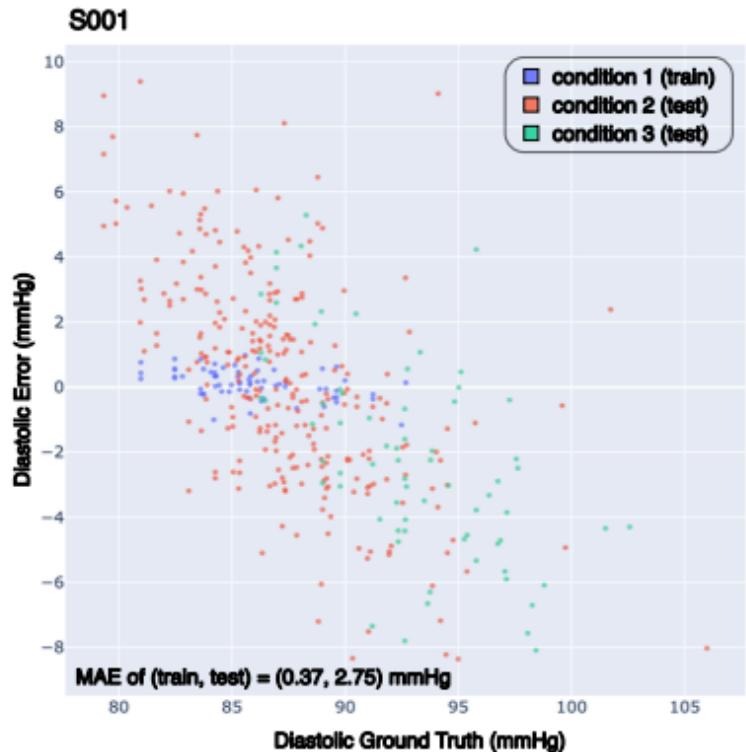
# Training

[1] Vaswani, A. et al. Attention Is All You Need. arXiv:1706.03762 (2017).  
[2] Perez, E. et al. FILM: Visual Reasoning with a General Conditioning Layer. arXiv:1709.07871 (2017).

↑ trainable → fixed



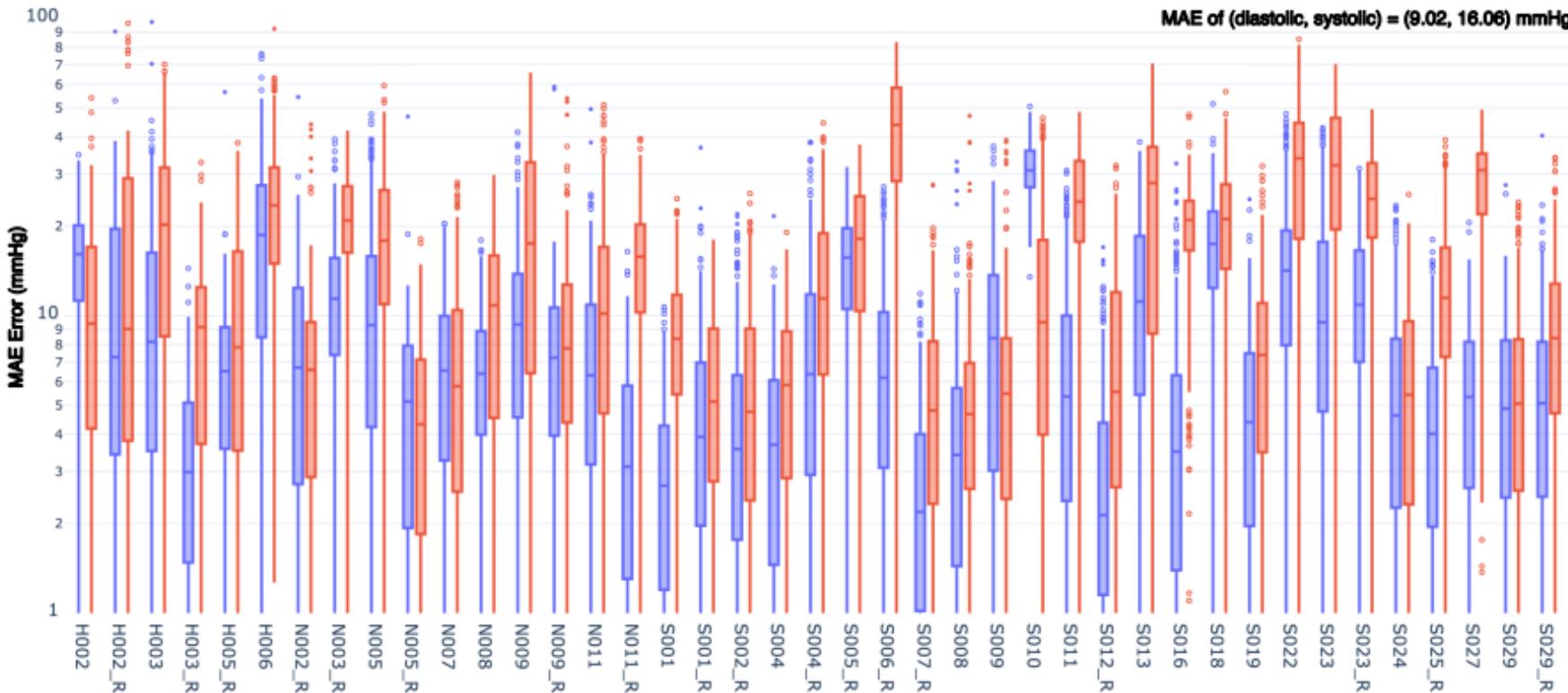
# Result: Stage 3



# Result: Stage 3

diastolic  
systolic

MAE of (diastolic, systolic) = (9.02, 16.06) mmHg

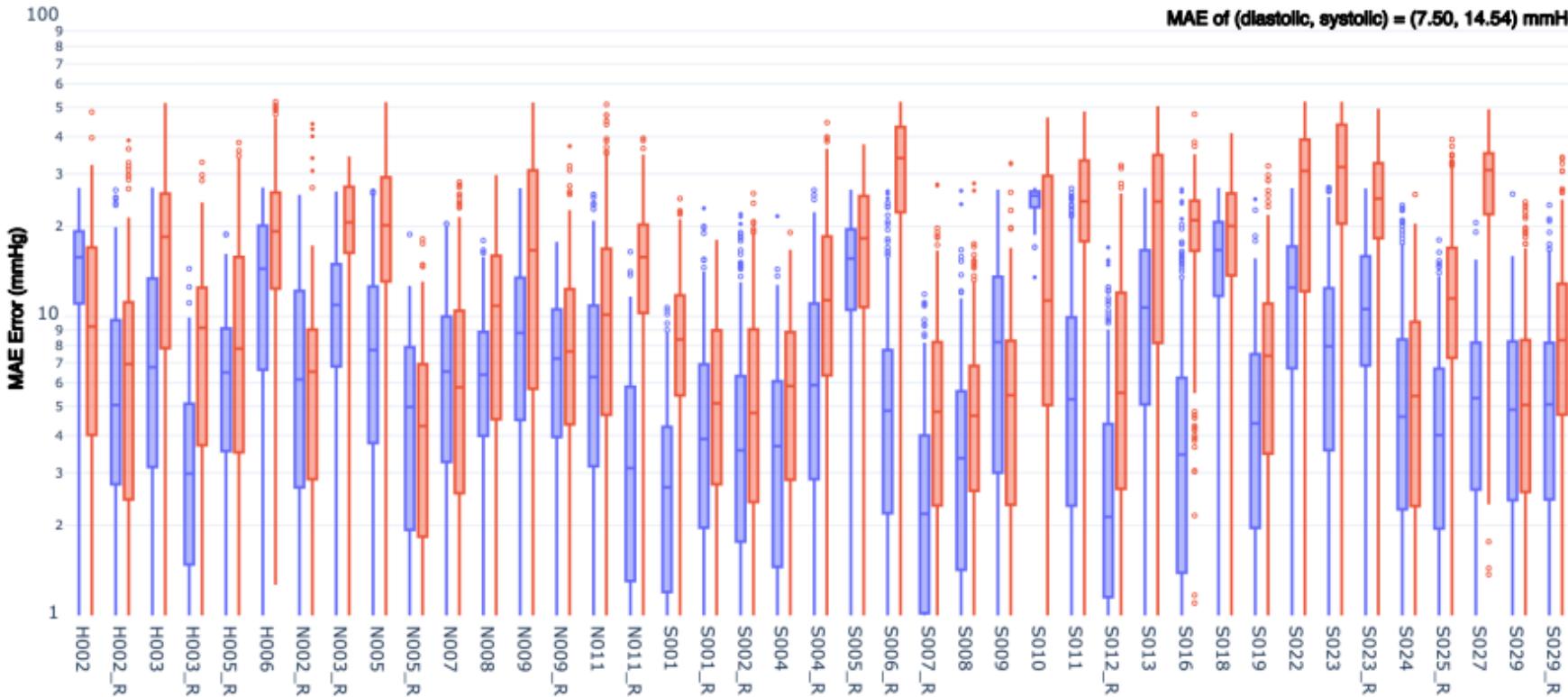


# Result: Stage 3

Filtered extreme value of BP: keep 13095 samples (92.5%); removed 984

diastolic  
systolic

MAE of (diastolic, systolic) = (7.50, 14.54) mmHg



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