TAPAS
Training Adapted Personalised Affective Social Skills with Cultural Virtual Agents

ANR AGENCE NATIONALE DE LA RECHERCHE

JST Japan Science and Technology Agency
CREST Symbiotic Interaction

RIKEN

Programs for Junior Scientists

Meta-Learning for Emotion Prediction from EEG while Listening to Music

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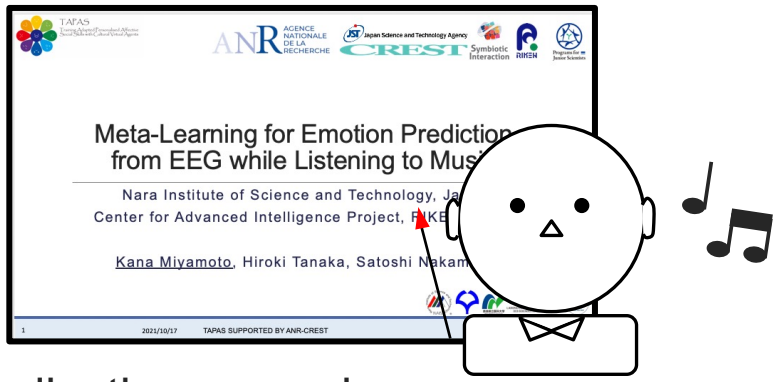
Emotion Induction using Music

Appropriate emotional induction is critical in mental health

Music

- Musical components influence emotions [Wallis+ 2011]
- Music is used to induce emotions [Sourina+ 2012]
- Music does not interfere with other activities



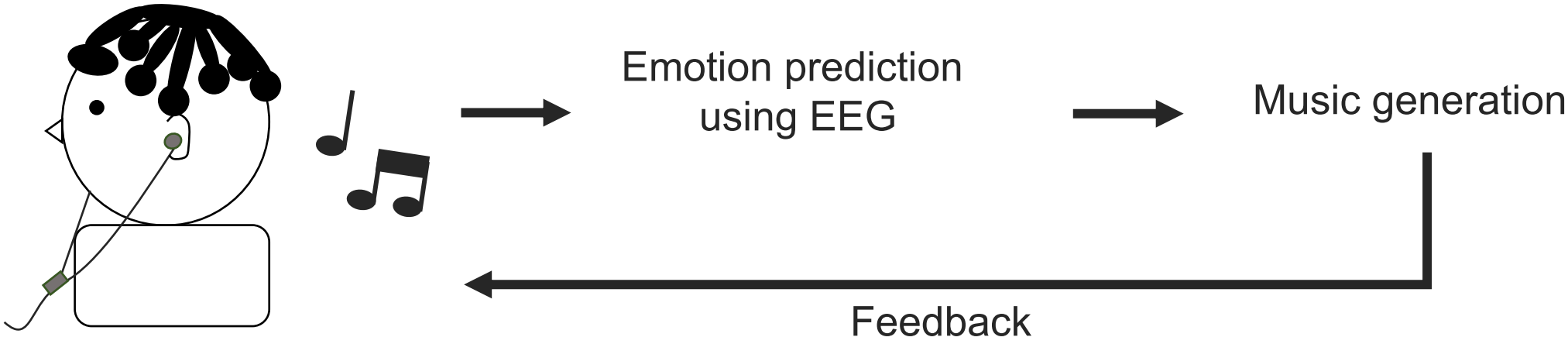
Application example
Emotional induction in presentation

- Emotions felt while listening to music vary depending on individuals and situations [Larsen+ 1991]

Personalized music is needed for emotion induction

Proposed Emotion Induction System

System generates music in real time based on participant's emotions

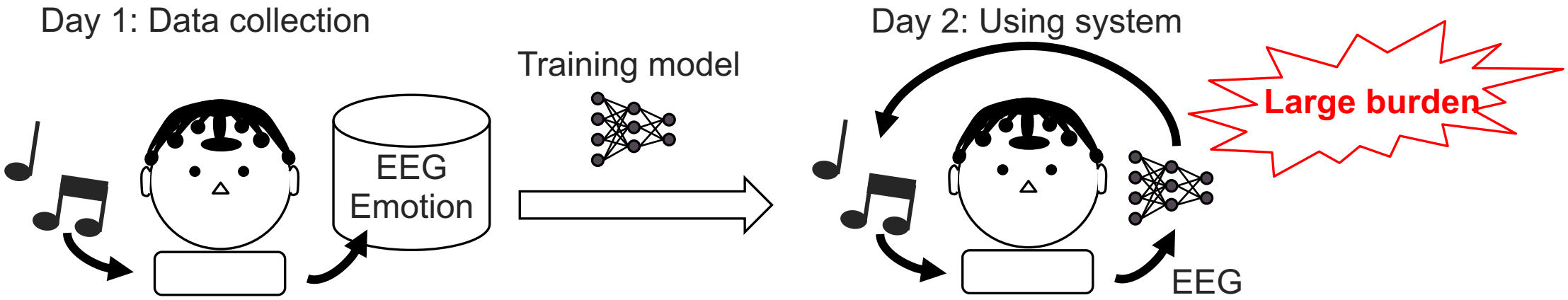


We demonstrated effectiveness of system [Miyamoto+ 2021 (Under review)]

Problem of Our Emotion Induction System

- Emotion prediction models were trained for each participant to consider individuality of EEG
- Long EEG recording was required to avoid lack of data

Process of using our system



Research objective

Predicting emotions with performance accuracy using **small amounts of EEG data**

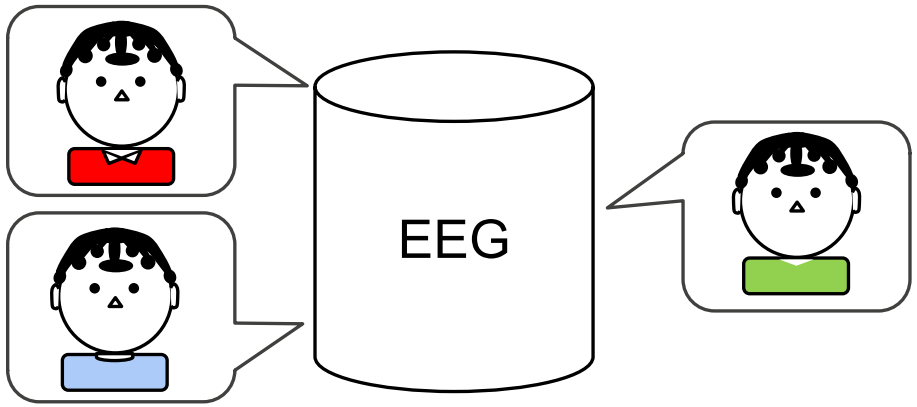
Training with Small Amounts of Data

Transfer learning

- Apply pre-training model to another domain
- Acquire highly accurate models with small amounts of data [Pan+ 2009]

Previous works using transfer learning for EEG [Lan+ 2008, Miyamoto+ 2020]

- Pre-training model treated EEG of **multiple participants** as one piece of data

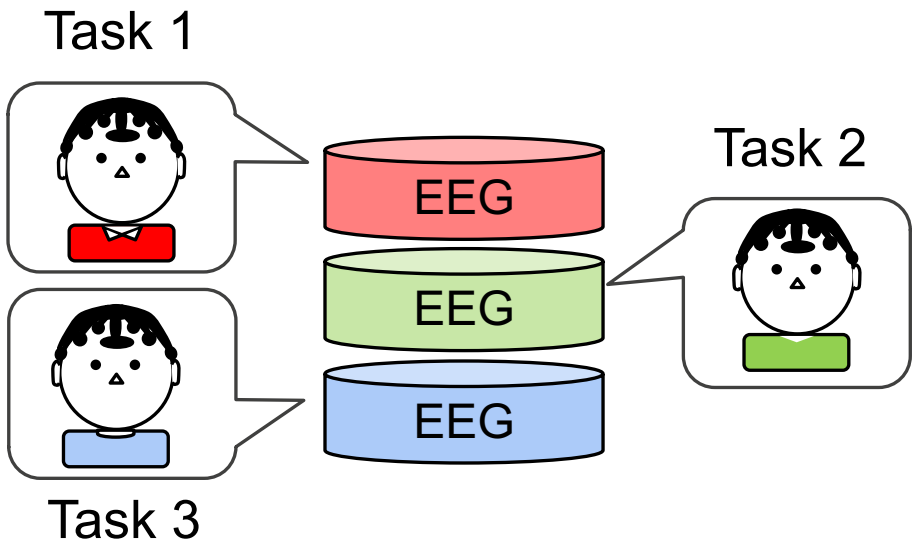


Training cannot take into account personal character of EEG

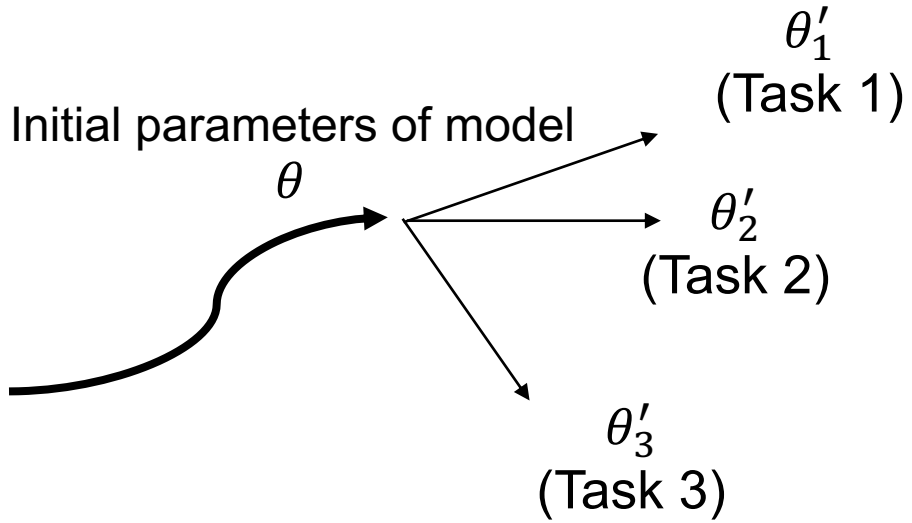
Model-Agnostic Meta-Learning (MAML)

Acquire initial parameters θ of model from tasks and adapts them to a target task [Finn+ 2017]

MAML in EEG research



One task is one participant's EEG



θ can easily be adapted to any participants

Related Works about Prediction using EEG with MAML

- Classification of sleep stages [Banluesombatkul+ 2020]
- Classification of motor imaginary tasks [Denghao+ 2021]
- Predicting emotions while watching music videos or movies [Duan+ 2020]

Music of auditory stimulation is necessary for construction of emotion induction system
We investigated whether MAML is also effective for EEG while listening to music

Research Overview

Research objective

Predicting emotions with high performance using small amounts of EEG data while listening to music

Methods

- Proposed method : Multiple participants' EEG with MAML
- Baseline method 1: Multiple participants' EEG without MAML [Lan+ 2008, Miyamoto+ 2020]
- Baseline method 2: Single participant's EEG [Ehrlich+ 2019, Miyamoto+ 2020]

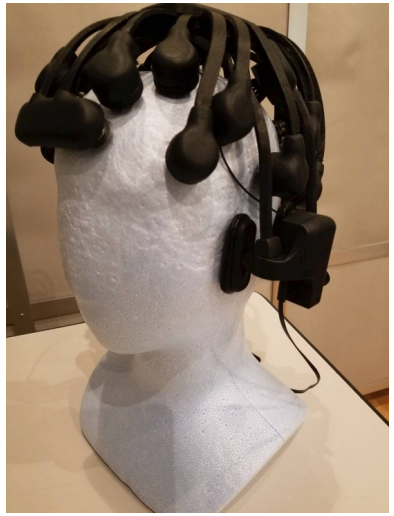
Hypothesis

Method with MAML can reduce error of emotion prediction compared to the other two methods

EEG Dataset

Dataset created in our previous work [Miyamoto+ 2020]

Participants	10 males, 10 females (age: 24.3 years)
Electroencephalograph	Quick-30 manufactured by CGX
Affective stimuli	41 pieces of music
Length of one piece of music	20 sec
Emotions	Valence and arousal (9-point scale between 0 and 1)

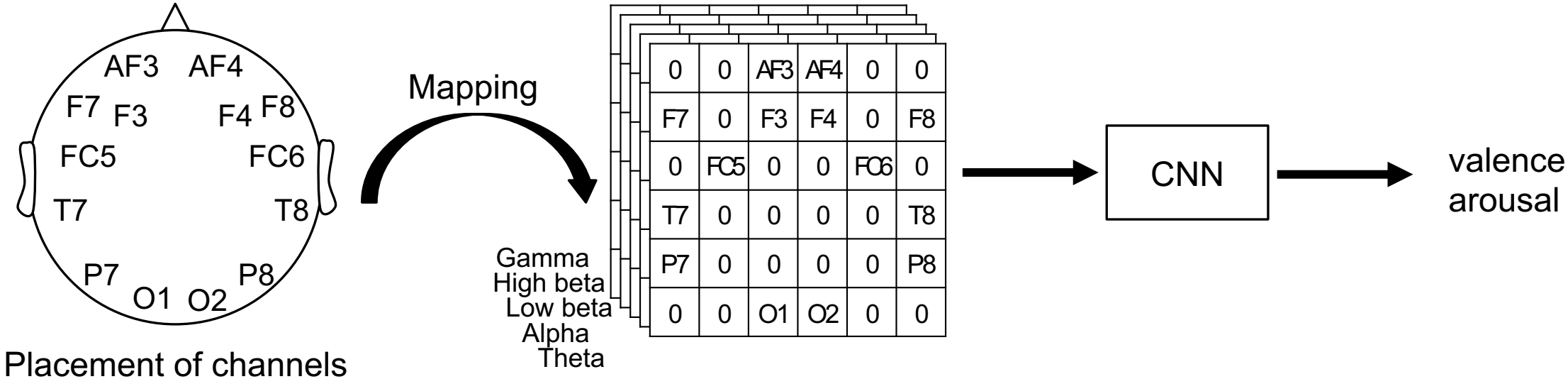


Quick-30

Features and Model

Preprocessing

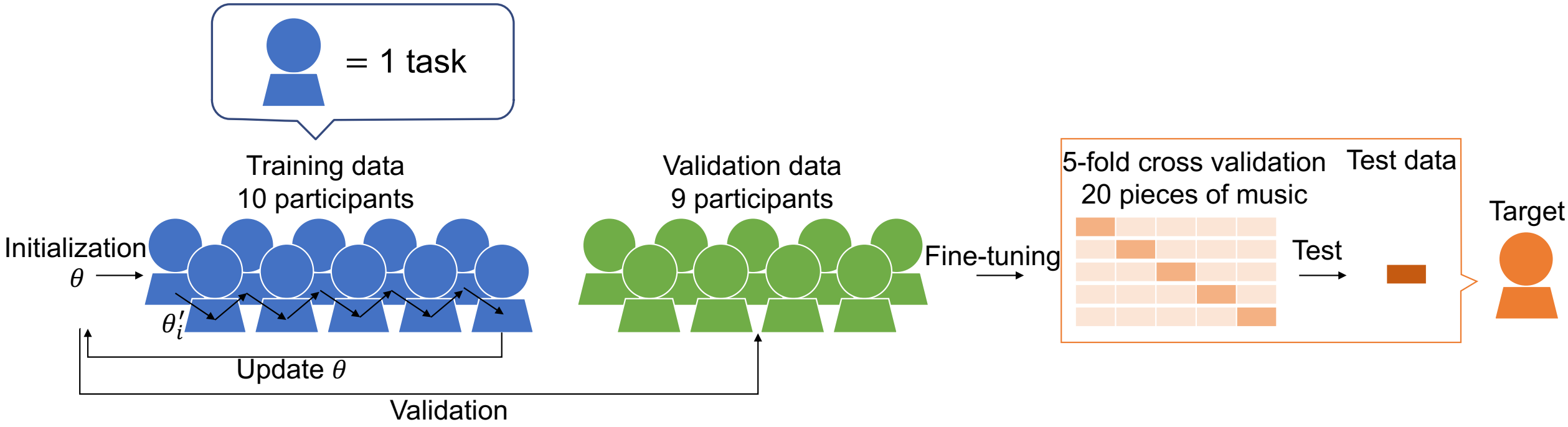
1. EEG while listening to music was divided into 1 sec
2. EEG was passed second-order IIR bandpass filters
3. Features for each of the five frequency bands $f = log(var\ (EEGdata))$
4. Mapped matrix reflecting the position of the EEG channels



Proposed Method

Multiple Participants' EEG with MAML

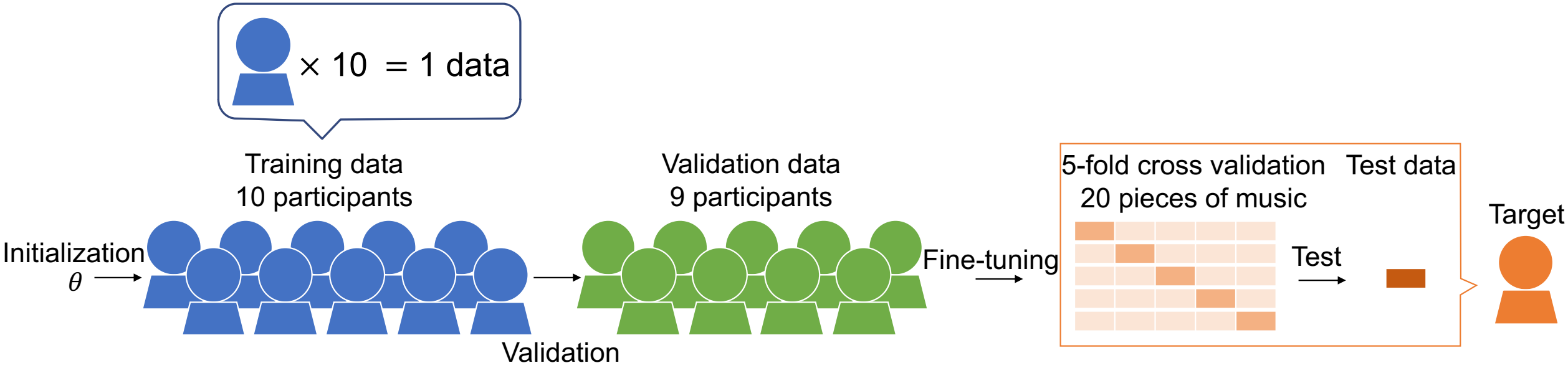
- Fine-tune model trained with MAML using a single target's EEG



Baseline Method 1

Multiple Participants' EEG without MAML

- Fine-tune model trained without MAML using a single target's EEG
- This method might not be able to grasp EEG individuality



Baseline Method 2

Single Participant's EEG

- Train model using only a single target's EEG
- This method might lack training data

Results

Range of labels of valence and arousal in dataset is between 0 and 1

There were significant differences by Wilcoxon signed-rank test in the following methods ($p<.001$)

- With MAML and Without MAML
- With MAML and Single par.
- Without MAML and Single par.

The means of RMSE for 20 participants

Proposed method With MAML		**Baseline method 1 Without MAML**		**Baseline method 2 Single par.**	
valence	arousal	valence	arousal	valence	arousal
0.244	**0.287**	0.300	0.321	0.367	0.377

RMSE is root mean square error between predicted values and label values

Conclusion

Summary of the results

Multiple participants vs. a single target participant

- Method using EEG of a single target considers individuality of EEG, but its performance was low

MAML vs. with MAML

- Using MAML had high performance
- MAML was effective in constructing our emotion induction system using music

Future work

- Applying models trained by MAML to our emotion induction system
- Investigating effects of reducing preparation time for using system