Analysis of selective attention processing on experienced simultaneous interpreters using EEG phase synchronization

Graduate School of Information Science, Nara Institute of Science and Technology

Haruko Yagura, Hiroki Tanaka, Taiki Kinoshita, Hiroki Watanabe, Shunnosuke Motomura, Katsuhito Sudoh, and Satoshi Nakamura

Simultaneous Interpretation (SI)

Simultaneous interpretation

➤ Interpreter according to the speaking speed of the speaker

Consecutive interpretation

➤ Speaker and interpreter alternate

Contents

➢Introduction:

-What brain function of experienced SI are excellent

-The problem of measuring Brain response for SI in real environment

-Proposed method:40-Hz ASSR

➢The methods for EEG measurement during SI

-Data acquisition and analysis ITC

➢Results and Discussions

Background

- Switching Attention Processing for SI

- 40 Hz-ASSR

- Proposed Method

Interpreter advantage

Training of SI changes the structure of brain function and improves the executive function related to attention and memory [Van de Putte, E., +2018] [Camayd-Freixas, E., + 2011]

Brain mechanism of experienced SI has been noted as expanding the possibility of training human attention and memory

The purpose of this study: Quantifying the brain function of experienced SI using EEG

Switch attention continuously during SI
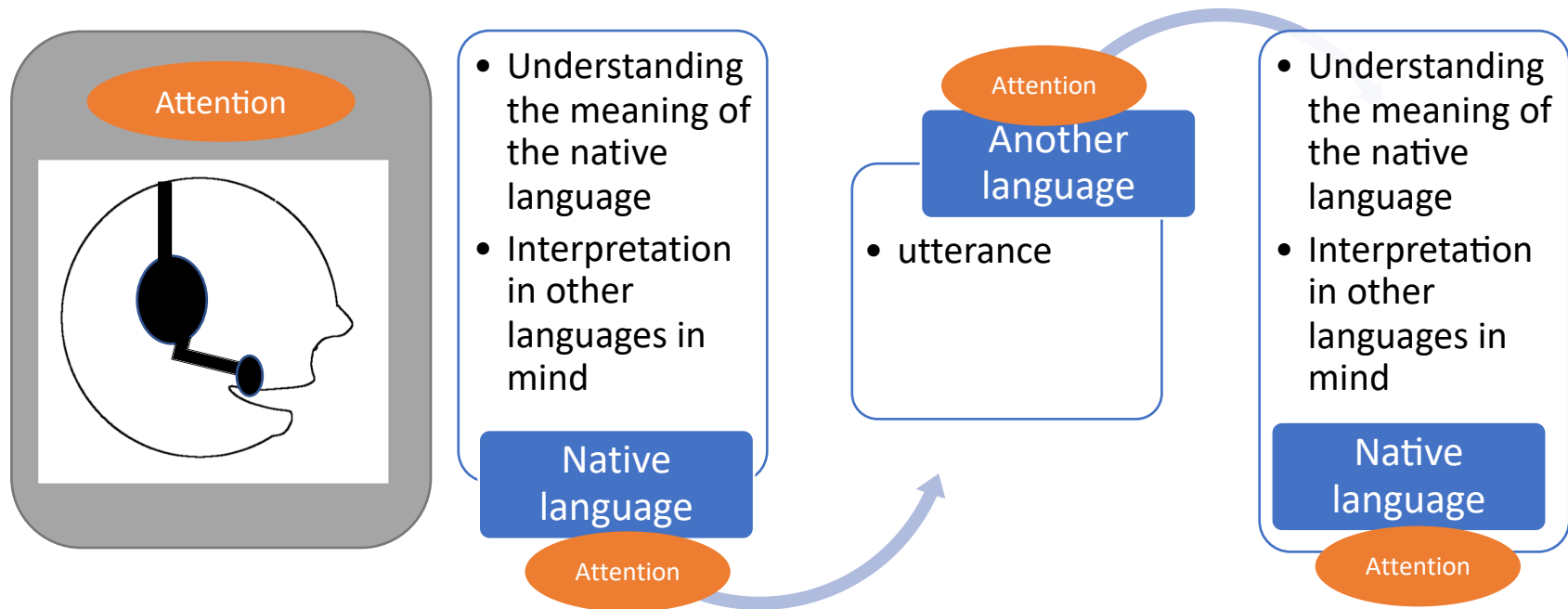
- SI requires continuous attention switching from the native language to another language which involved selective attention processing [Cowan,N,2000 +]- Multilingual Control, [Morels, J.,+,2015] - Executive function

The Difficulty of EEG measurement in the real environment for SI
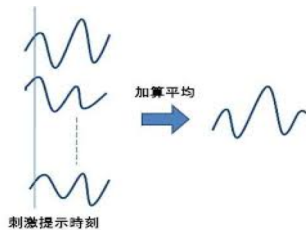
- **Original sounds which is not edited；**

50歳近く年下の20代の女性との婚約を明らかにしたイタリアのベルルスコーニ前首相76歳が

- **Shortened and edited sound stimulus for comparison between conditions；**

50歳近く	年下の	20代の	女性との	婚約を	明らかにした	イタリアの	ベルルスコーニ	前首相
Cond1:	Cond2	Cond3	Cond1	Cond1	Cond2	Cond2	Cond1	Cond1

- ➢ Repeat short stimuli for Controlling experimental conditions
  - Additive Average Processing (EEG)
  - Block design (fMRI)

➢ **The selective attention processing which occurs continuously during SI cannot be verified.**

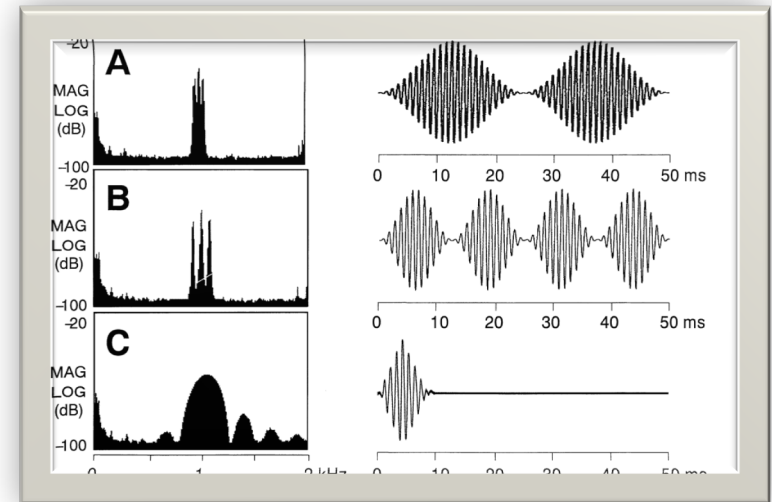# Proposed method; 40 Hz-Auditory Steady-State Response (ASSR)

Present with target stimulus

Associated with selective attention [Mu¨ller, N+,2009] [Griskova.B, I.+, 2011]
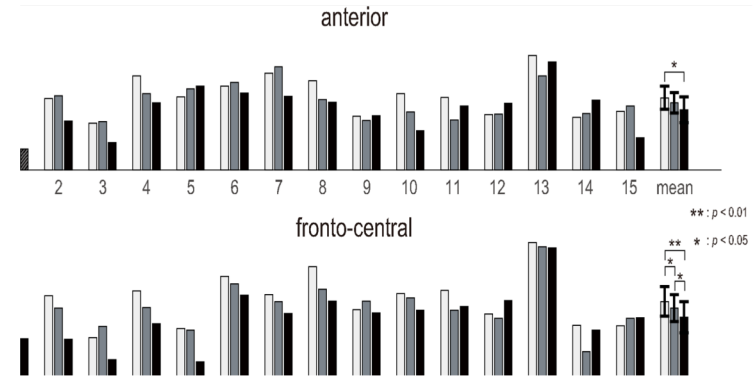
Very short pulse sound

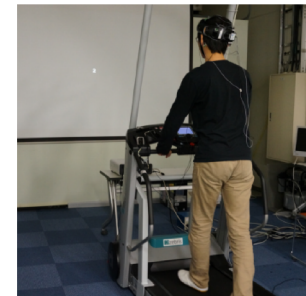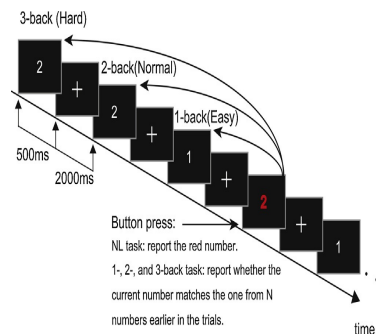Robust against environmental changes

40 Hz-ASSR

- Extraction of phase-locked response and calculate ITC value induced from 40Hz-ASSR

- ASSR presented at the same time the target stimuli such as n-back task during walking with a lot of noise such as body movement

- Succeeded in extracting suitable response during walking using ITC

anterior

fronto-central

$** : p < 0.01$
$* : p < 0.05$

N-back

3-back (Hard)
2-back(Normal)
1-back(Easy)

500ms
2000ms

Button press:
NL task: report the red number.
1-, 2-, and 3-back task: report whether the
current number matches the one from N
numbers earlier in the trials.

time

The ITC value (index indicating phase synchronization in the brain)

The value of ITC

Phase synchronization

High：max 1

Phase synchronization

Low：min 0

The value of ITC
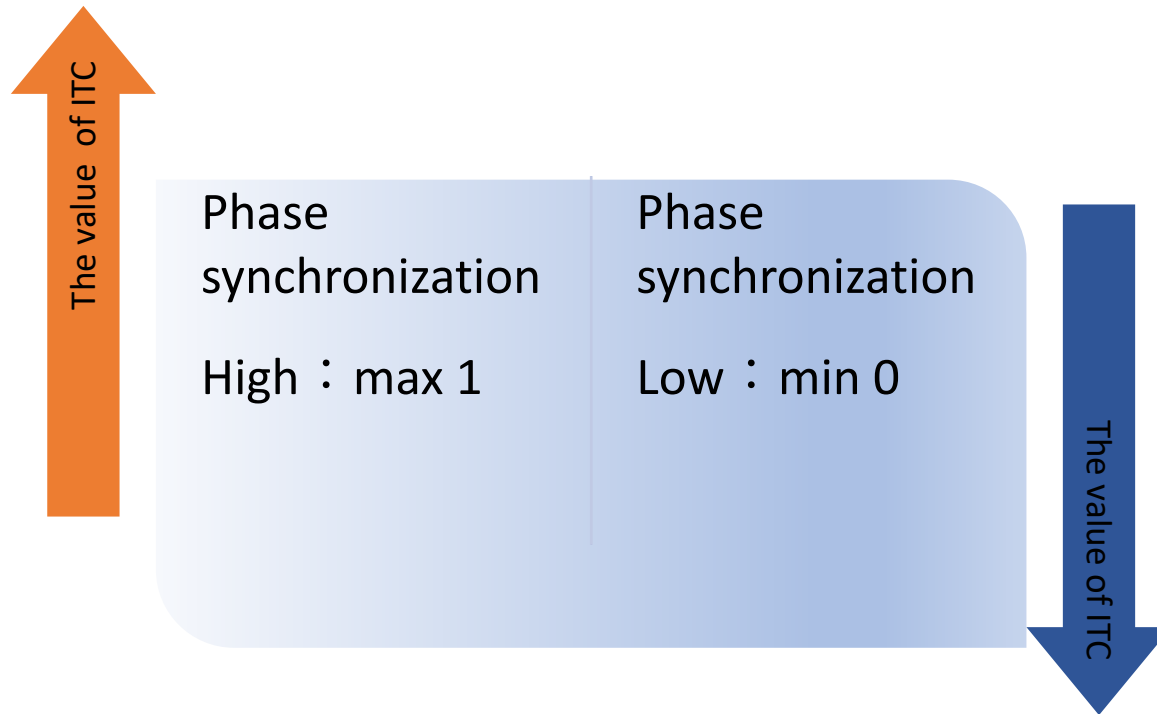
Proposed method: 40Hz-ASSR and ITC values are used for extracting selective attention processing during SI

The use of ASSR

Experimental conditions close to the real environment

■Less likely to be affected by vibrations at frequencies lower than 40 Hz (body movement, blinking, etc.)

■Since the ASSR signal is presented at the same time as the SI voice, there is no need to edit the voice.

The previous method

Different from the real environment

■ Control experimental conditions

■ Unable to detect continuous attention switching

Proposed method

Objective of the study:

- Verification of selective attention for experienced SI in real environment using EEG signals

Proposed method:

- Extract ITC value induced from 40Hz-ASSR during SI (target task)

Methods:

- Subjects

- Sound Stimuli and Experimental Tasks

- ITC value and hypothesis

Subjects:

■ 22 Japanese female interpreters

：range; 46-71 years、 mean= 53.4 years、 SD = 6.6

・C rank (less than 1 year of simultaneous interpretation experience): n = 15

・S rank (15+ years of simultaneous interpretation experience): n = 7

➤ Prior to the experiment, we obtained informed consent in writing approved by the ethics committee of NAIST

Sound Stimuli: Present 40Hz ASSR and Japanese voice at the same time

■ **Presents 8 kinds of topic Japanese radio news on both ears**

- The duration of each of the eight Japanese sounds were 60 seconds

- Sound pressure is normalized by maximum amplitude

- Sound pressure level for pulse tones adjusted to 5% of maximum news sound amplitude

- Japanese voice is presented without editing source sounds

Japanese sounds

Pulse tone for ASSR
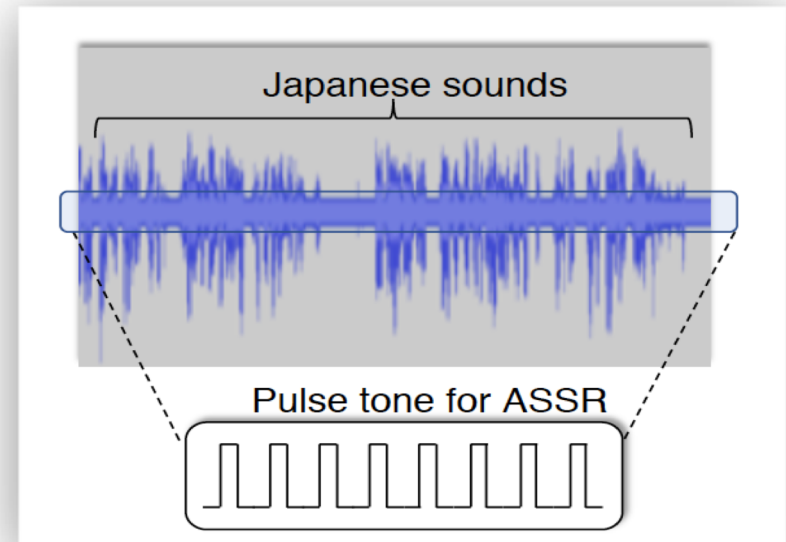
EEG settings

■ Using wireless EEG

- EEG devices; CGX Quick-30 Dry EEG Headset
- Preprocessing with low data：
  sampling rate：500
  bandpass filtered：1-50Hz
  ground electrode: FpZ

Stimuli Sequences

- SI condition：
  Simultaneous
  Interpretation

  (Japanese to English)

- SH condition：Shadowing

  (Japanese to Japanese)

- Under conditions, 8 kinds
  of topics are presented
  randomly for 60 seconds
  after instructions for 2
  seconds.
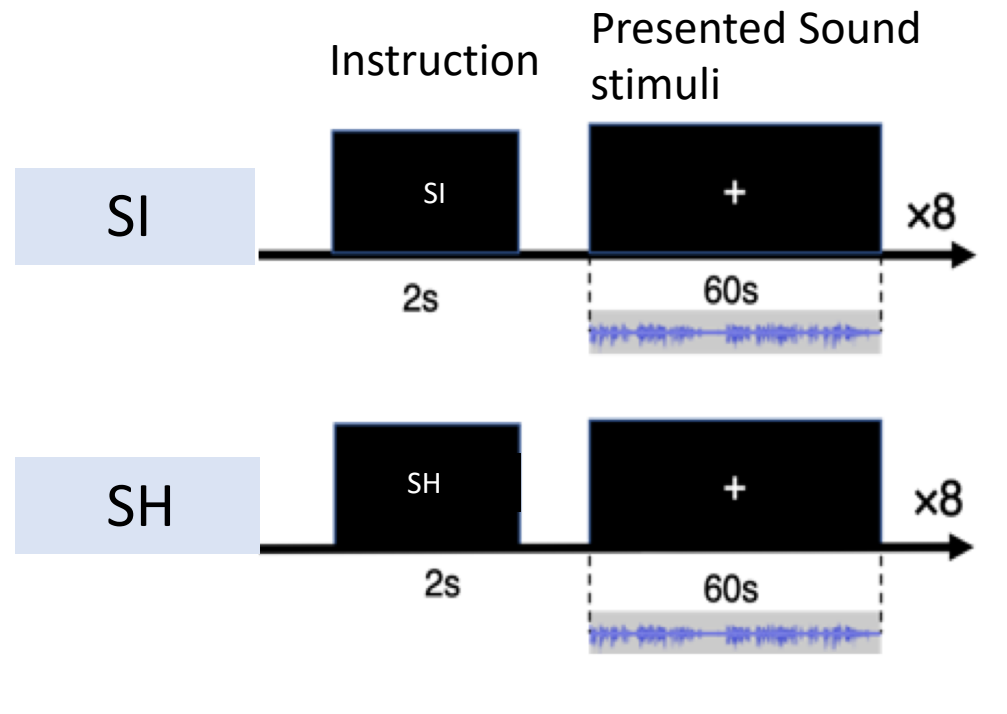
Analysis: Comparing ITC values between conditions

■Calculate ITC value for each condition

- For each subject, divide the EEG data obtained for each experimental condition and topic into 3-second trials while overlapping each second.

- After performing a discrete Fourier transform on each of the divided trials, calculate the ITC value with the right formula

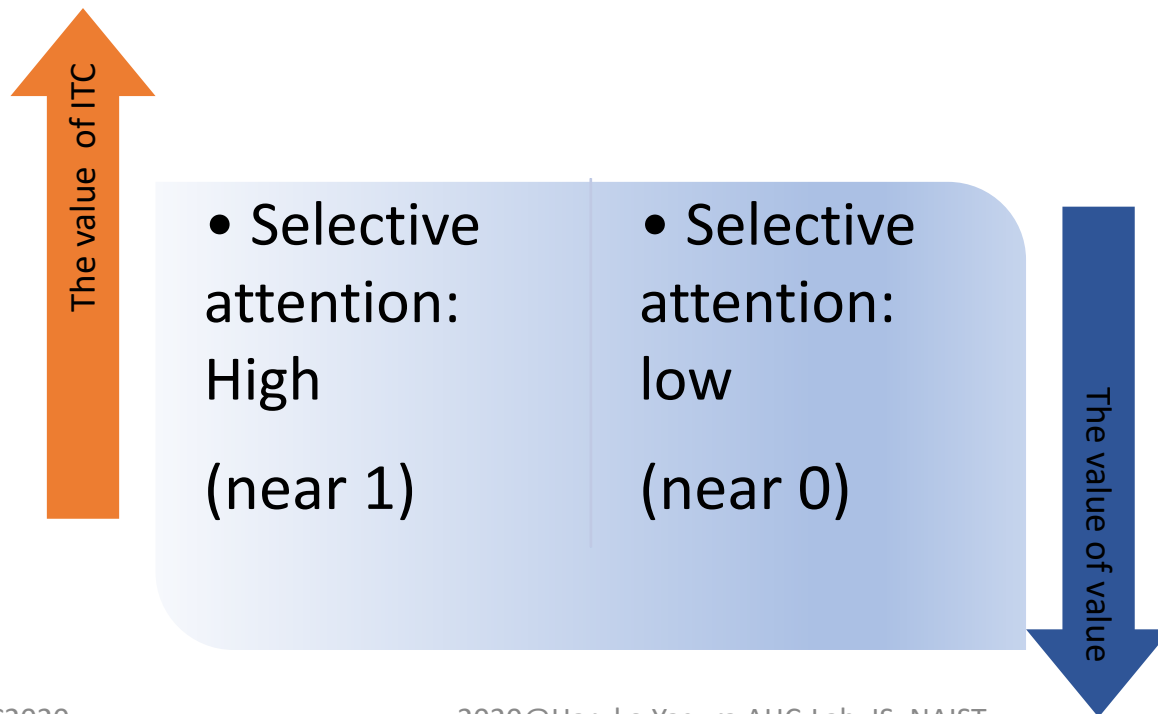- ITC calculates the average of three frontal lobe electrodes (F3, Fz, F4)[Griskova+2011]

$$ITC[ch] = \left| \frac{\sum_{k=1}^{K} exp(j\theta_k^f[ch])}{K} \right|$$

- ➤ where f is a frequency, ch is the channel number, f
- ➤ k is phases of frequency f and electrode ch, k is a trial number, and K is the number of trials. ITCs were calculated for
- ➤ each news over the three central electrodes (C3, Cz, and C4). ITCs were then averaged over the electrodes
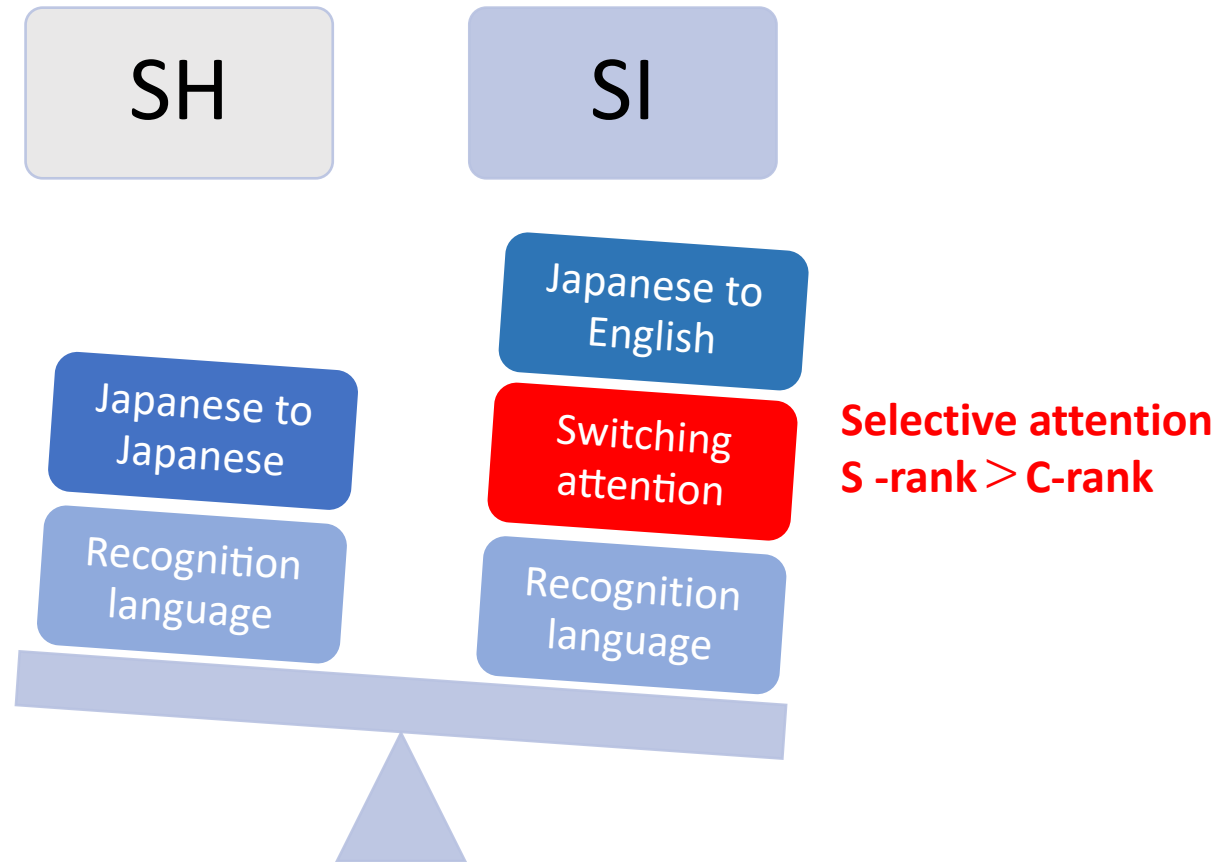
ITC value and selective attention

- 40Hz-ASSR amplitude and phase-locked response increase as selective attention ability increases
  [Mü̈ller, N+,2009] [Griskova.B, I.+, 2011] [Parciauskaite V.,2019+]

The value of ITC ↑

- Selective attention: High

  (near 1)

- Selective attention: low

  (near 0)

The value of value ↓

Hypothesis; SI-S rank> C rank

ITC：

SH

SI

Japanese to English

Japanese to Japanese

Switching attention

Selective attention
S -rank ＞ C-rank

Recognition language

Recognition language

Subjective Evaluation

- Performed after the EEG experiment

- 5 questions are set for each of 8 topics

- level 5- most difficult, level 3 -normal, and level 1- most easy

Q1: achievement for interpretation

Q2: topic field

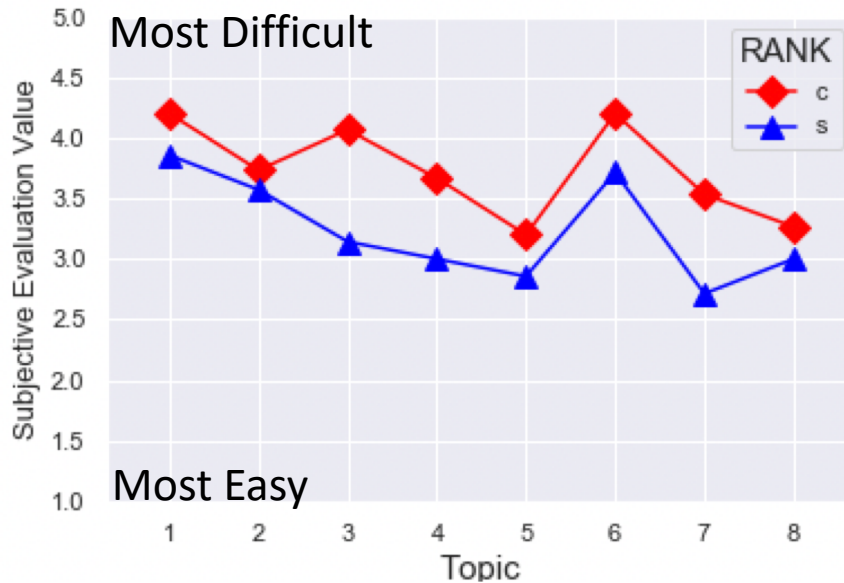Q3: voice speed

Q4: a comfortable voice for listening

Q5: Overall interpretation difficulty

Results and discussion

- Subjective Evaluation

- ITC value

Subjective Evaluation Value

- **2 way - factorial ANOVA - 8 topic ✖ 2 ranks (C and S)**
- Main effect(rank; $F_{1,160}=$ 12.7、 $p< 0.001$; topic:$F_{7,160}=$ 4.3、 $p< 0.001$)
- Subsequent test; C > S (p. < 0.001)

➢ C rank is rated higher than S rank
➢ Reflects difficulty of interpreting due to lack of years of experience

ITC value
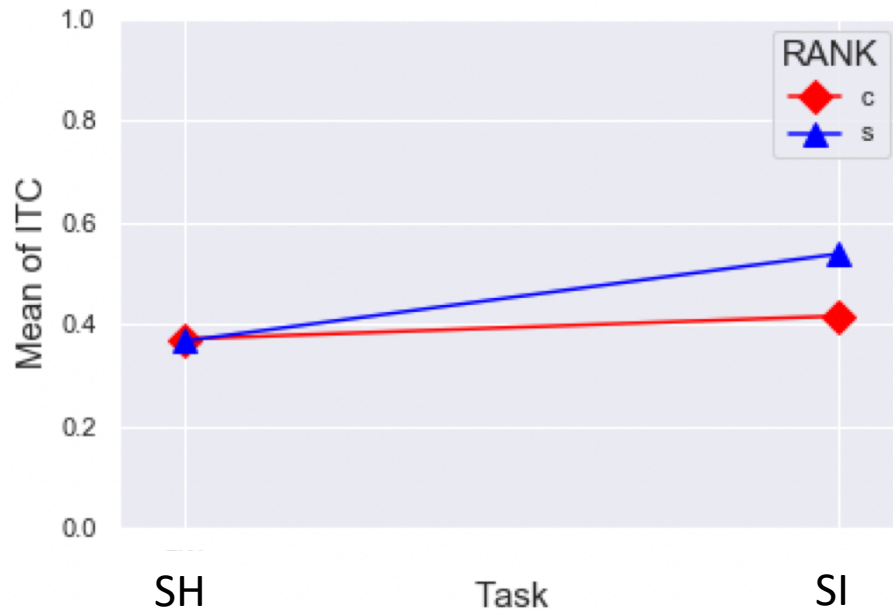
- **2 way - factorial ANOVAs : 2 task (SI and SH) ✖ 2 ranks (C and S)**
- Main effect; rank ($F_{1,348} = 7.5$, $p<0.001$) and task ($F_{1,348} = 18.1$, $p<0.001$)
- Interaction ($F_{1,348} = 8.6$、 $p< 0.01$)
- Subsequent test;
  SI:S > C($p<0.001$)
  SH: n.s

➢ **Verified the hypothesis**

Conclusions

- We used 40 Hz-ASSR-induced ITC values to verify selective attention processing with experienced SI.

- ITC value under SI condition was significantly higher in S rank than in C rank but not observed in the SH condition. It verified the our hypothesis

- We proposed that 40Hz-ASSR phase-locked response is effective as a method to quantify the selective attention processing of experienced SI in the real environment.

Future works

➢ The following points could not be verified in this experiment, so it is a future works.

- Temporal change of selective attention

- Relationship between difficulty level of each topic and years of SI experience.

Thanks for your attention