Clinical Validation Studies on the Assessment Accuracy of Alzguard-D and Treatment Efficacy of Alzguard-T

- Nov 25, 2022 -

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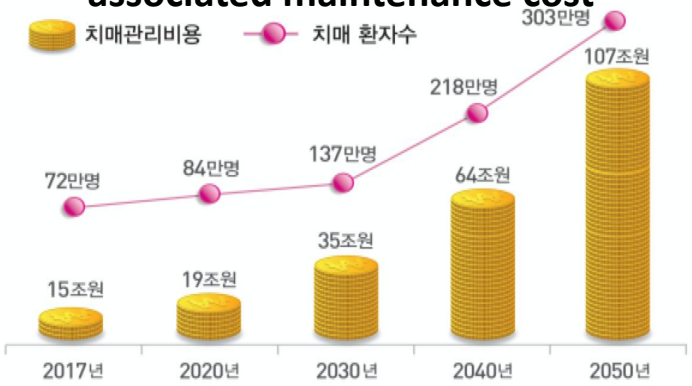
Background

Early Screening and treatment can reduce the incidence of dementia by 33%. However, the cost of the current screening tool are $1,000~1,800 and inconvenient. That causes rising of Mobile, VR screening tools.

Rapid increase in dementia patients and associated maintenance cost



- Expenditure on dementia patients and care has soared every year.
- Social cost savings are more than 7.9 trillion dollar due to dementia screening
- Dementia care costs in 2050, $84 trillion dollar(Every 10 years, 78%↑)

The importance of early screening of dementia

Risk of Alzheimer Disease

33%

- Early diagnosis and treatment of dementia have reduced patients' risk of Alzheimer's by 33% in numerous studies. Starting with the 2015 *FINGER study, it has been further developed in several studies around the world

*Kivipelto, M., Solomon, A., Ahtiluoto, S., Ngandu, T., Lehtisalo, J., Antikainen, R., ... & Soininen, H. (2013). The Finnish geriatric intervention study to prevent cognitive impairment and disability (FINGER): study design and progress. *Alzheimer's & Dementia*, *9*(6), 657-665.

Rising of Mobile, VR Tool to diagnosis/treat Dementia

hannover re®
neurotrack

- In terms of dementia detection, amyloid PET, MRI, Blood Test are very expensive, around $1,000~1,800, and hard to access since patient has to visit a hospital. Hence, mobile and VR-based dementia tool which have short test time and highly accessible, are being released on the market. For instance, Neurotrack Company, a digital healthcare company, provided digital assessment technologies to track and manage patient cognitive health.

Background

Many studies have shown that keystrokes, voice/language, and eye-tracking markers can accurately screen early stage of dementia, namely Mild Cognitive Impairment

Keystroke Marker

(Keystroke dynamics maker)

Sensor: touch screen, keyboard & stylus

Keystroke features

- total number of interactions
- typing session length
- latency between successive key presses (Press-Press Latency) and releases (Release-Release Latency)
- time between a key press and subsequent release (Hold Time)

170 elderly patients
(83 men, 87 women; M age = 82.1yr., SD = 6.2)
specificity = 0.91, sensitivity = 0.52

Voice/Language Marker

(Voice and language maker)

Sensor: Microphone

Speech and language features

- Vocal reaction time in (seconds)
- Relative length patient sentence duration clinician sentence duration
- Amount of silence (0 to 1 continuous scale)
- Amount of insertions (0 to1 scale)
- Amount of deletions (0 to 1scale)
- Irregularity-first order (arbitrary units)
- Irregularity-second order (arbitrary units)

Between HCs and those with **MCI, 79% ±5%**
Between HCs and those with **AD, 89% ±3%**
Between those with **MCI and those with AD, 80% ±5%**

Eye-Tracking Marker

(Eye-tracking maker)

Saccade/Anti-Saccade

- latencies for all correct saccades in the antisaccade
- concentration score
- Face Rect, Rotation, Position
- eye movement error-correction
- Time stamp(ms)
- Eye Movement State

80 elderly patients
HC(n = 27), MCI(n = 26), AD(n =27)
MMSE AUC=0.904, eyetracking AUC=0.888
*ADAS-Cog, FAB, CDR와도 높은 상관관계 입증

Keystrock dynamics maker: Rabinowitz, I., & Lavner, Y. (2014). Association between finger tapping, attention, memory, and cognitive diagnosis in elderly patients. Perceptual and motor skills, 119(1), 259-278.
Voice maker : Tablet-Based Automatic Assessment for Early Detection of Alzheimer's Disease Using Speech Responses to Daily Life Questions
Eye-tracking maker : Oyama, A., Takeda, S., Ito, Y., Nakajima, T., Takami, Y., Takeya, Y., ... & Katayama, T. (2019). novel Method for Rapid Assessment of cognitive impairment Using High-performance eye-tracking technology. Scientific reports, 9(1), 1-9.

Study 1: A clinical validation study of the assessment accuracy of early screening of mild cognitive impairment using AlzGuard-D.

Alzguard-D : Tool for screening early stage of MCI

Cognitive Task	Stroop test (**Executive function**; Scarpina et al., 2017)
	Symbol association (**Associative recall**; Troyer et al., 2008)
	Self-ordered pointing task (**Visual working memory**; Geva et al., 2016)
	Arithmetic (**Working memory**; Kasai et al., 2020)
	Sentence memorize and speak (**Logical memory**; Wechsler Memory Scale; Sullivan et al., 2018)
	Picture Description (**Language**; Rentoumi et al., 2014; Ahmed et al., 2013; Nicholas et al., 1985; Tomoeda et al., 1996)
Voice biomarker	Sentence memorize and speak (**Logical memory**; Wechsler Memory Scale; Sullivan et al., 2018)
	Picture Description (**Language**; Rentoumi et al., 2014; Ahmed et al., 2013; Nicholas et al., 1985; Tomoeda et al., 1996)
Eye tracking biomarker	Smooth pursuit (**basic oculomotor**)
	Saccade (**Attention and inhibitory control**; Crawford et al., 2005)
	Anti-Saccade (**Inhibitory dysfunction**, **working memory**)

Alzguard-D : Cognitive Impairment Screening Tool

1. High Usability

Actual User gives 2.89 for Usability Testing

(7-point scale, lower score means higher usability)

2. Biomarkers + Cognitive Responses

Data collecting from Voice, Eye-Tracking, Cognitive Response marker Collecting data from 289 Testers

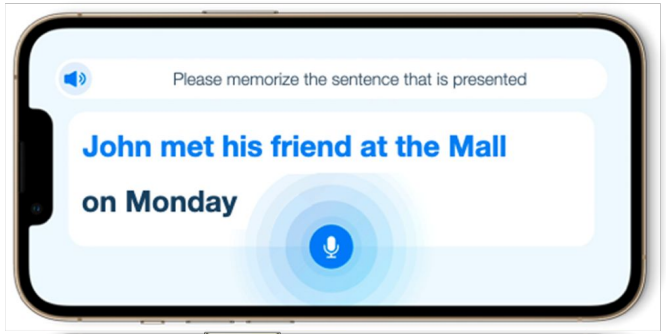
3.High Accuracy

AI analysis, Natural Language Processing

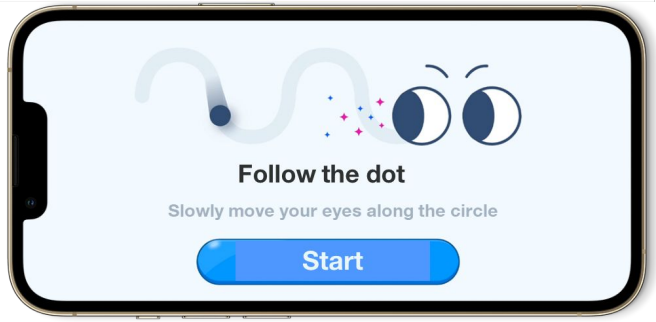
Current AUC 0.876

alzguard

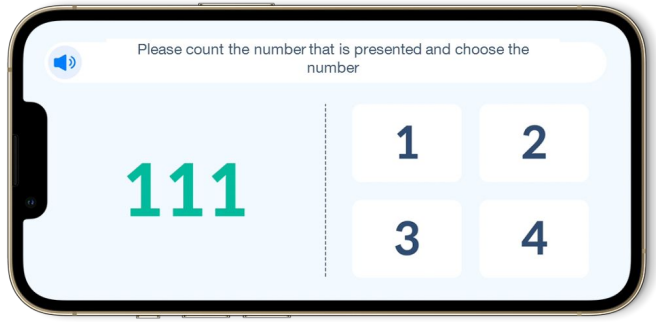
Voice/Speech Task



Eye-Tracking Task



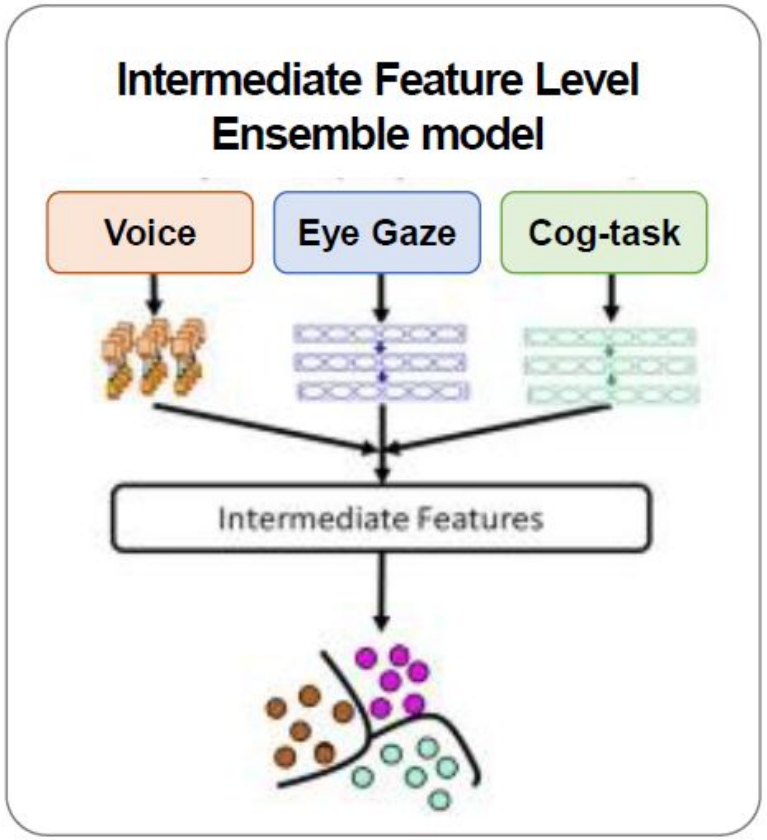
Cognitive Response Rate Task



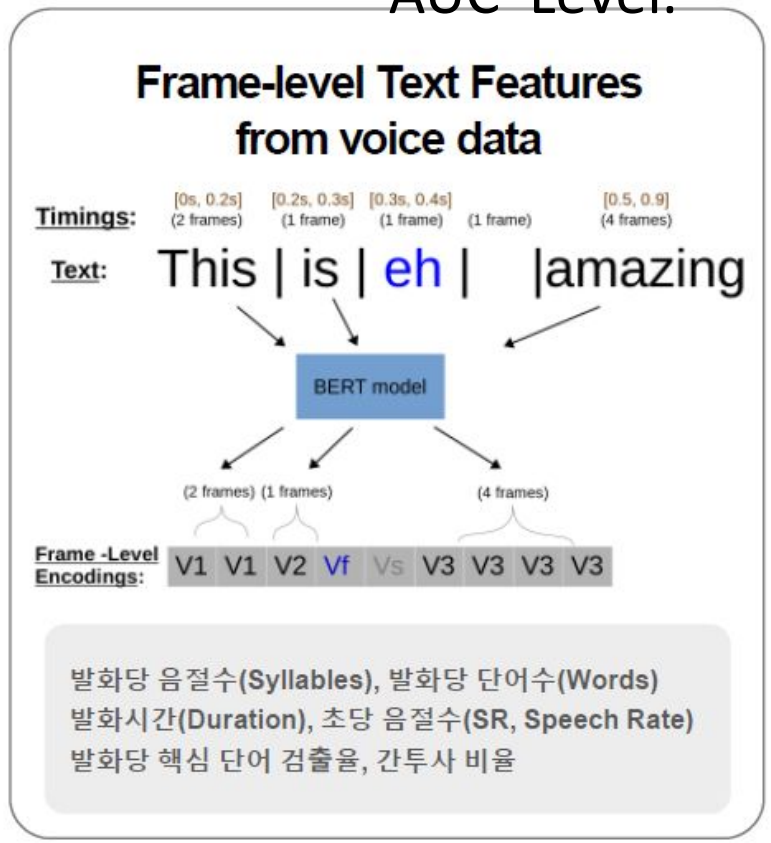
AI model using data collected from AlzGuard-D

AI model – Overview

Stacked Ensemble model : to reflect the characteristics of data and results simultaneously.
Structured and non-structured data can be processed simultaneously to achieve the high AUC Level.



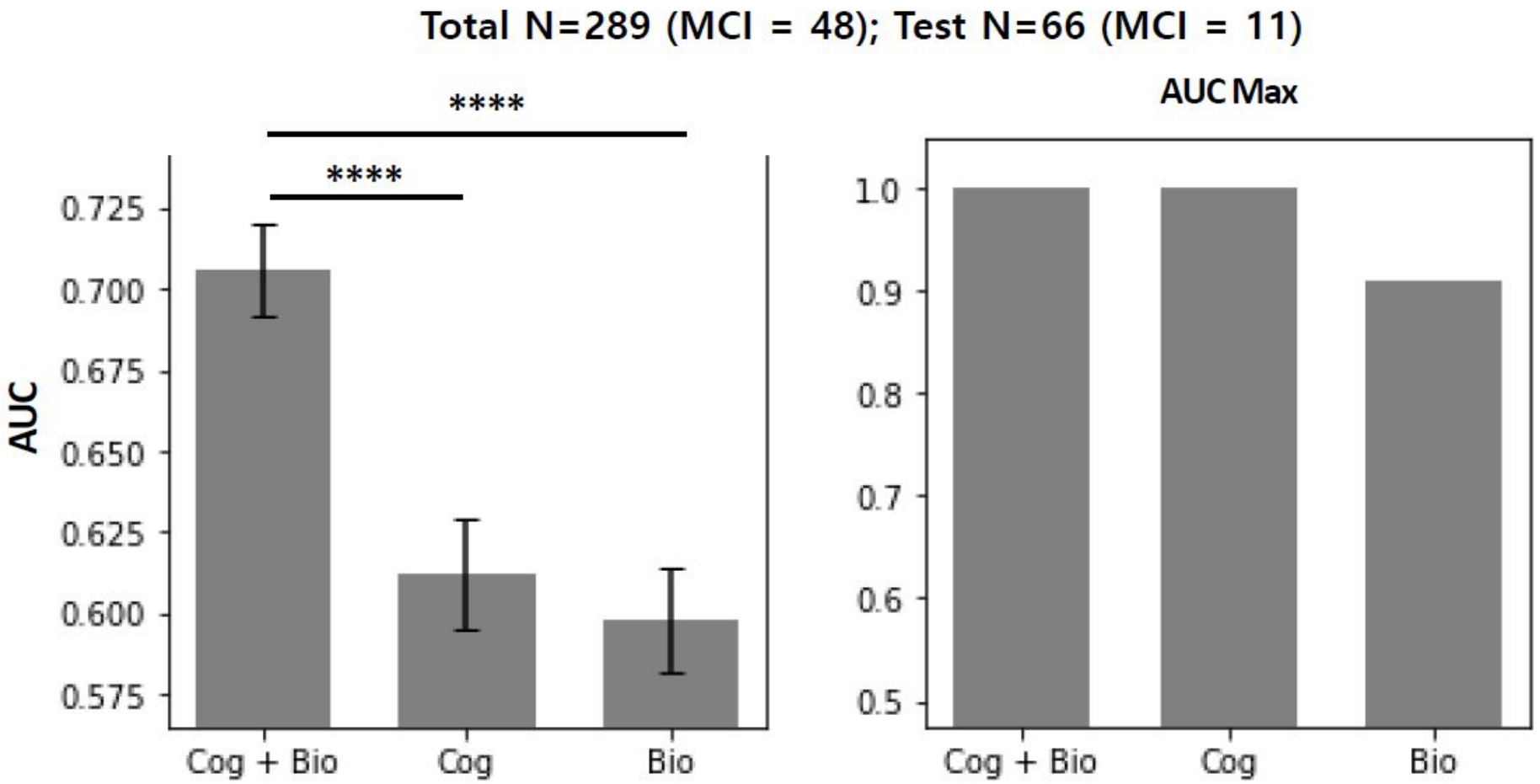
Although automatic speech recognition software is commercially available, its **accuracy in mental health settings has not been well described…**



AI model – Validation on the effects of addition of bioma

Statistically significant increase of AUC when Biomarkers are added to existing cognitive assessment tasks.

(100 simulations on the screening model; paired t-test; p < 0.000)



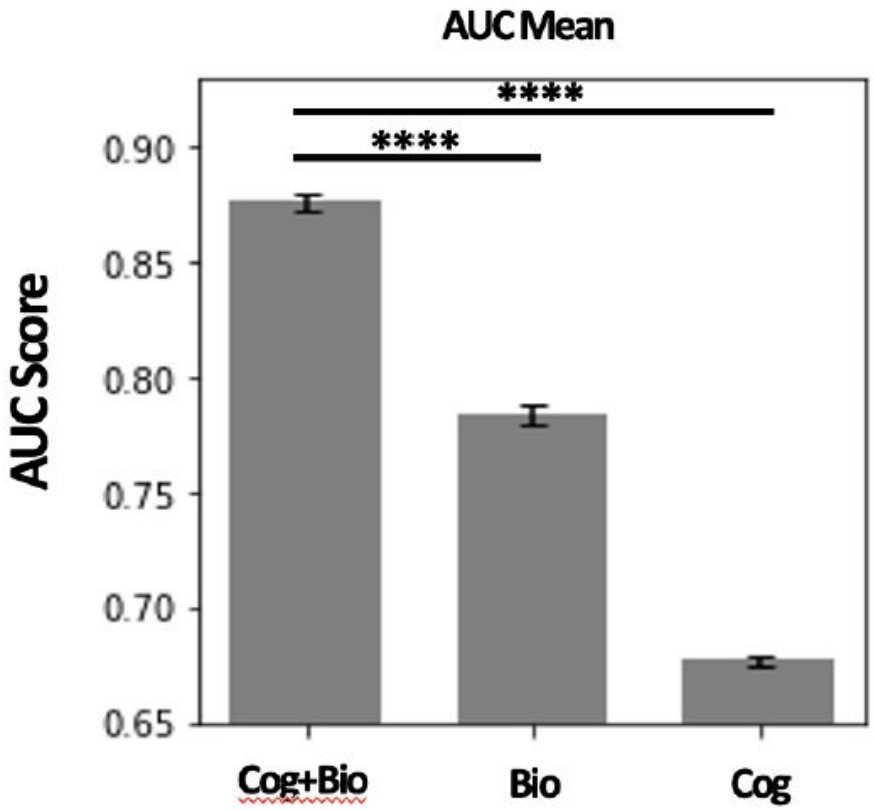
AI model – Performance

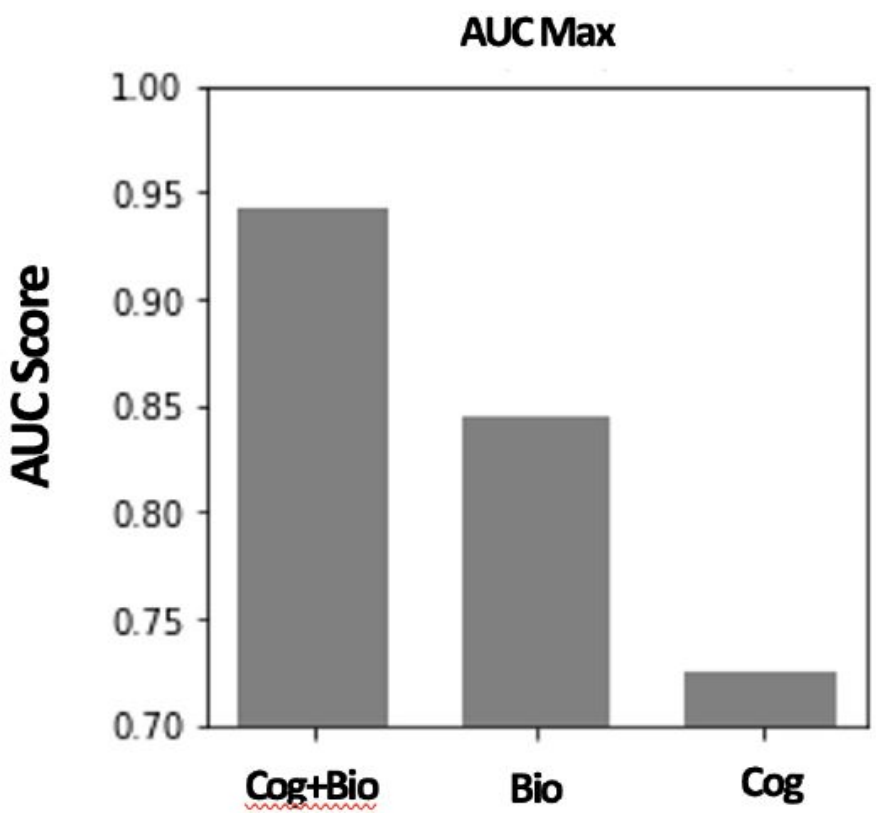
Highest AUC when Biomarkers are added and CatBoost model is used.

(20 simulations on the screening model; paired t-test; $p < 0.000$)

Cog+Bio AUC Score : 0.876 (max : 0.942)
Bio task AUC Score : 0.783 (max : 0.845)
Cog task AUC Score : 0.677 (max : 0.726)

Total N=289 (MCI = 48); Test N=66 (MCI = 11)



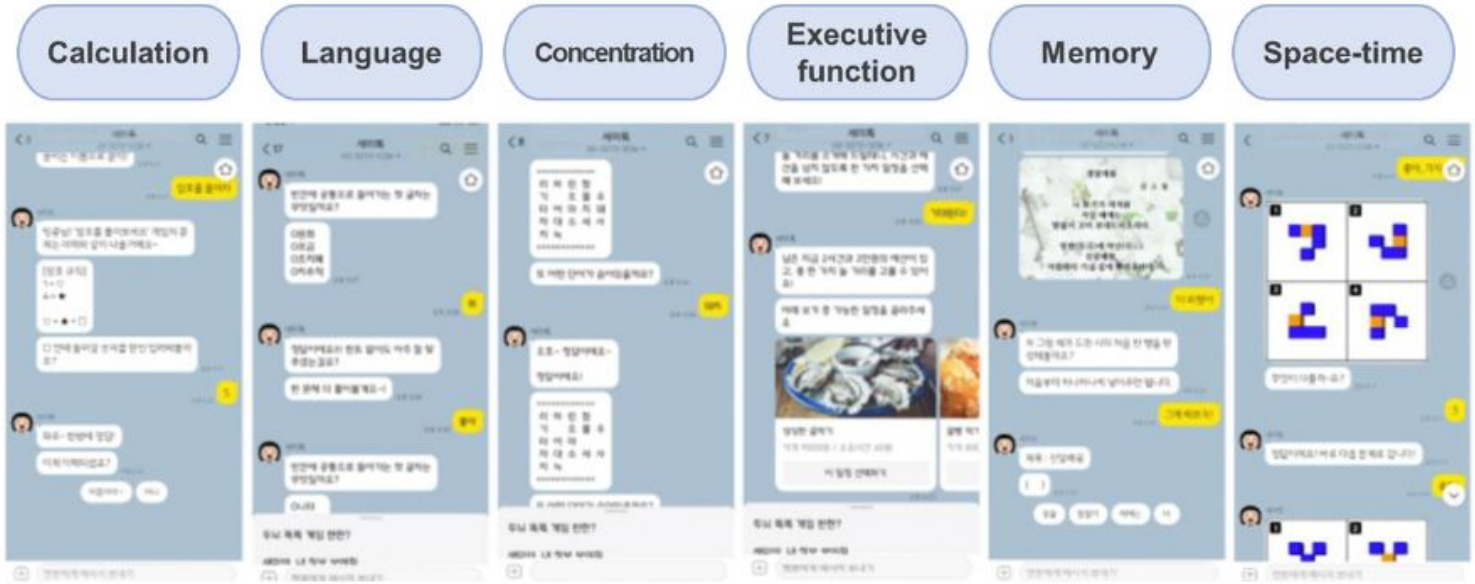


Interim message

- We proposed the hybrid form of digital screening means to capture the various cognitive functions
- We implemented a stacked ensemble AI model for early screening of the people in potential risk of mild cognitive impairment
- We took an intermediate feature level ensemble approach
- Instead of using “End to End” paradigm, we employed Frame level Text Features from voice recording
- Biomarkers clearly played a crucial role in the prediction as a complementary onto neuropsychological data
- The model successfully showed relatively high score on AUC, 0.876 on average 0.942 max.

Study 2: A clinical validation study for efficacy of digital therapeutic using AlzGuard-T

AlzGuard-T (Care-and-Cure)

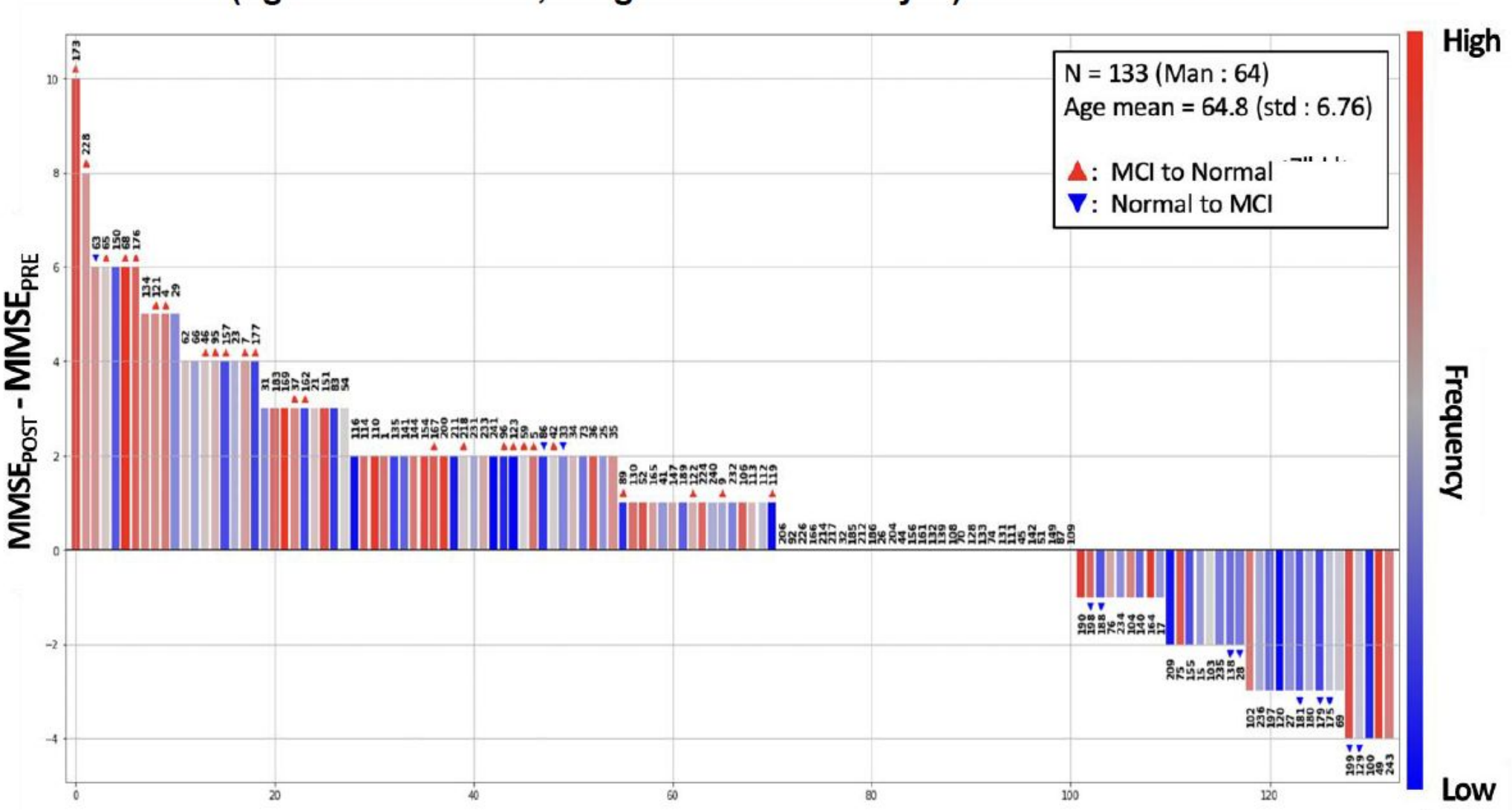


- *Sammy* subserving chatbot-based games for improving six categories of high-level cognitive functions.
- Users are required to carry out four sets of games per day to achieve a daily mission given by *Sammy*.

- *Smart masil bang* is a group chat for five or more people gather in messenger room and take care of each other's safety.
- In the messenger room, people encourage each other to play brain training games, or greet and talk freely with others every day.

Changes in cognitive functions of participants

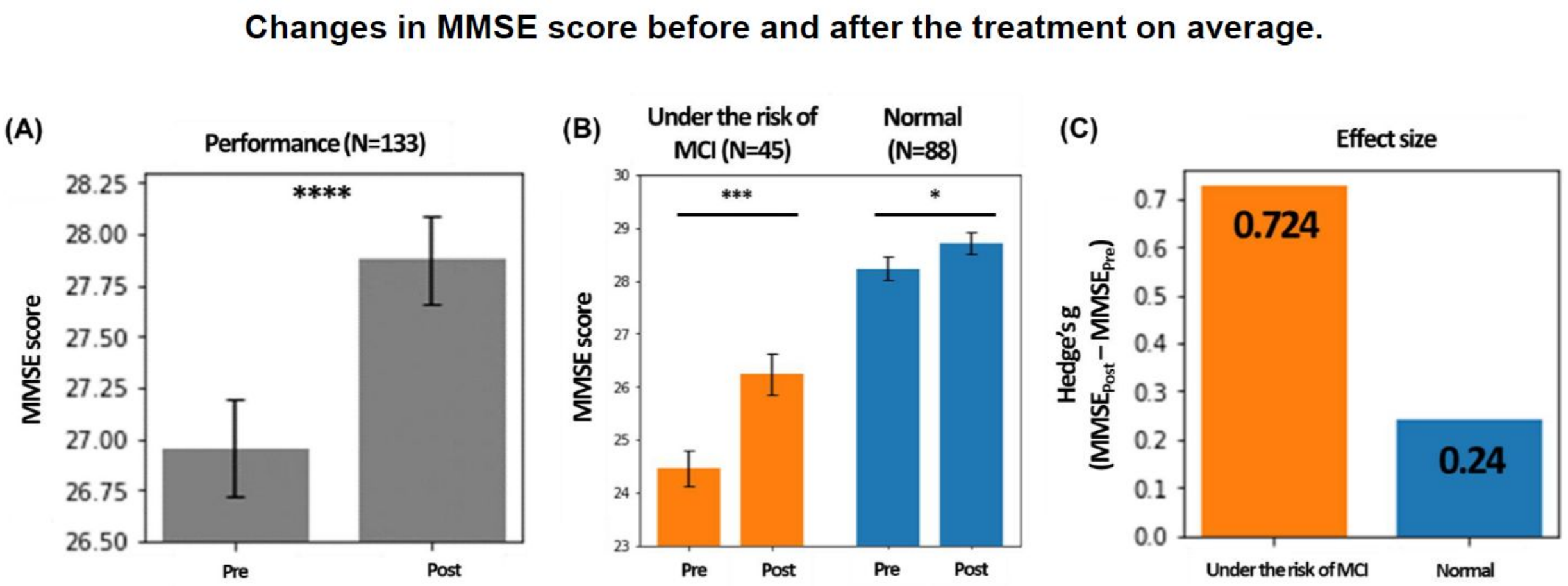
N=133 (age mean = 64.75, range from 50 to 80 yrs). Intervention: 12 weeks.



** K-MMSE (30 questions)

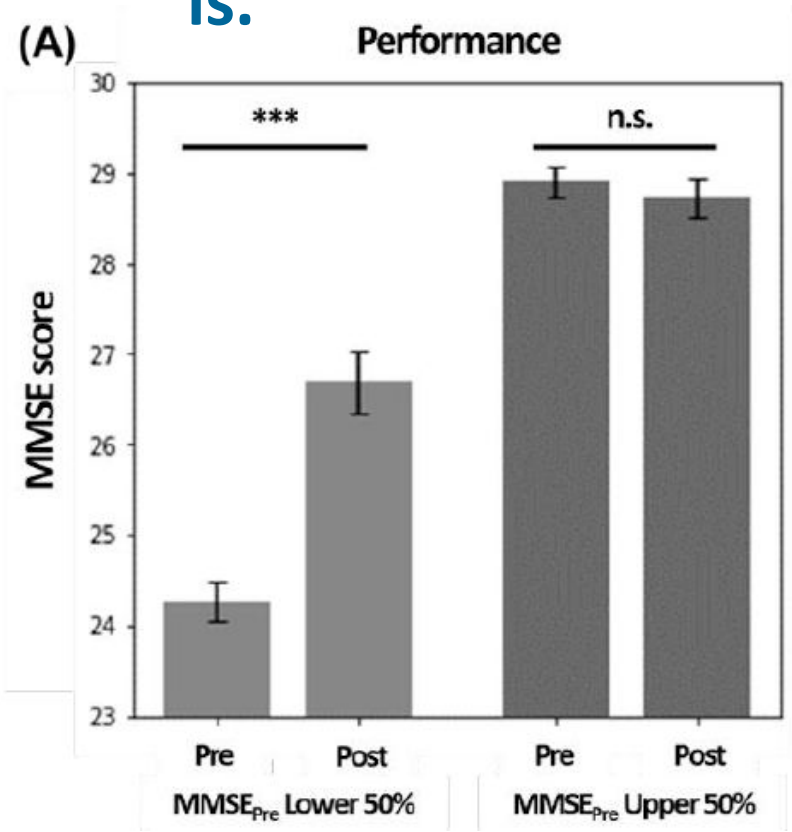
Overall result

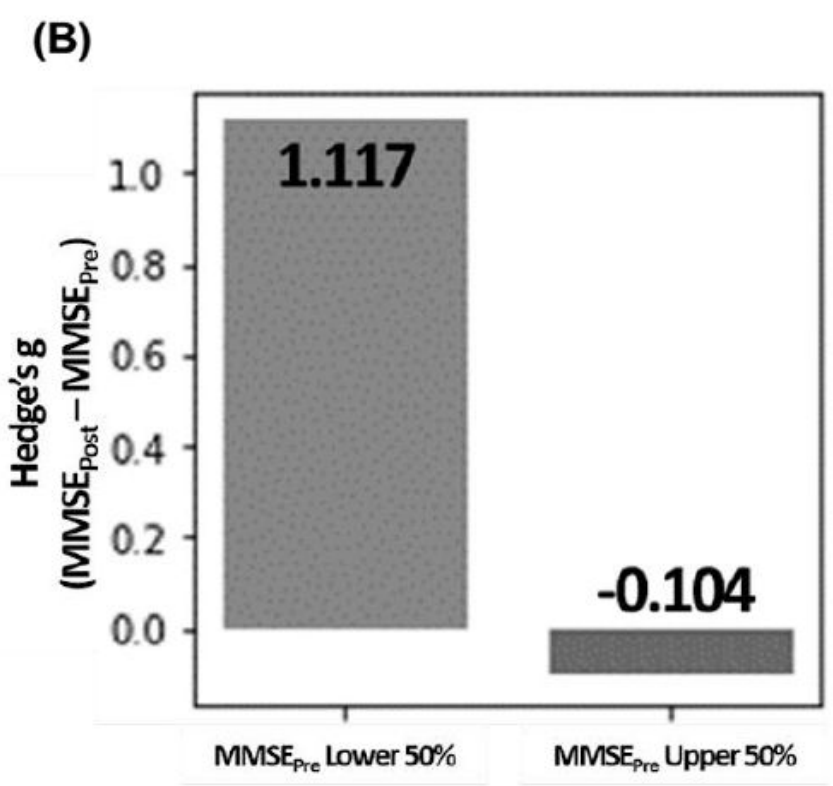
✔ AlzGuard-T significantly improves the cognitive function

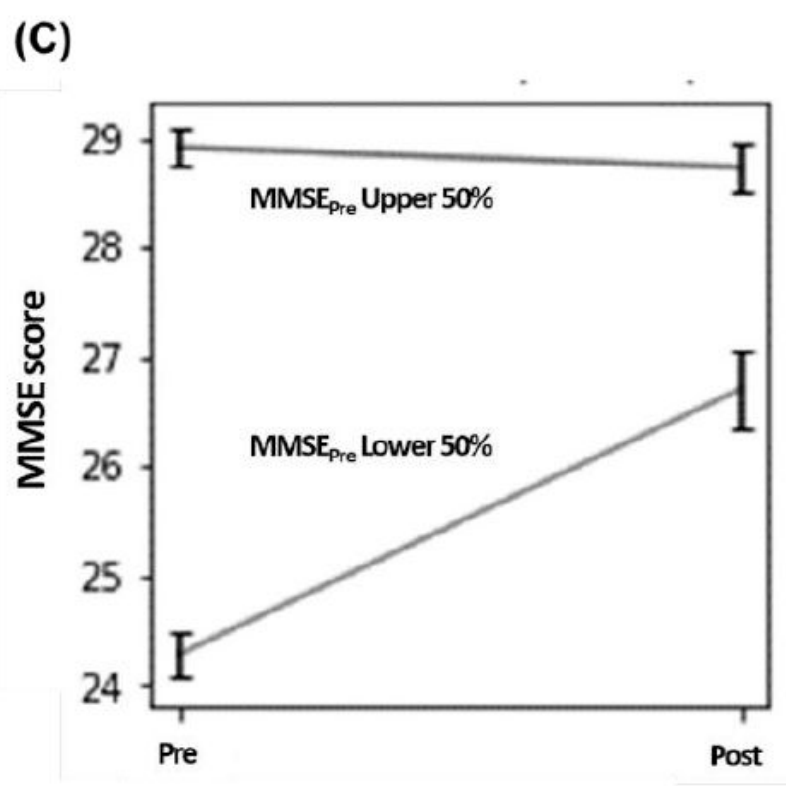


Performance improvement

✔ **The lower the MMSE score before the treatment, the higher the effect is.**

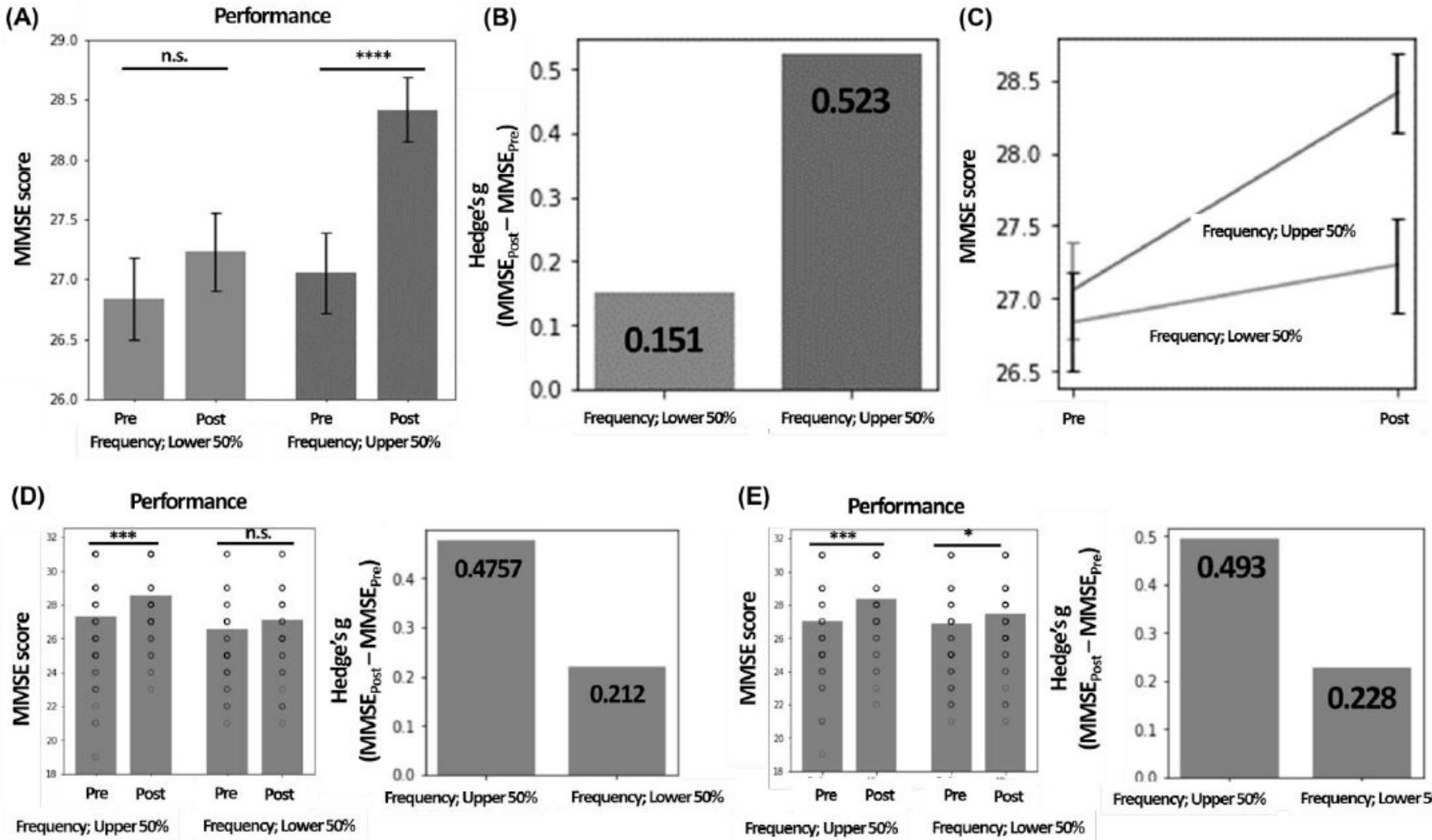






Performance improvement

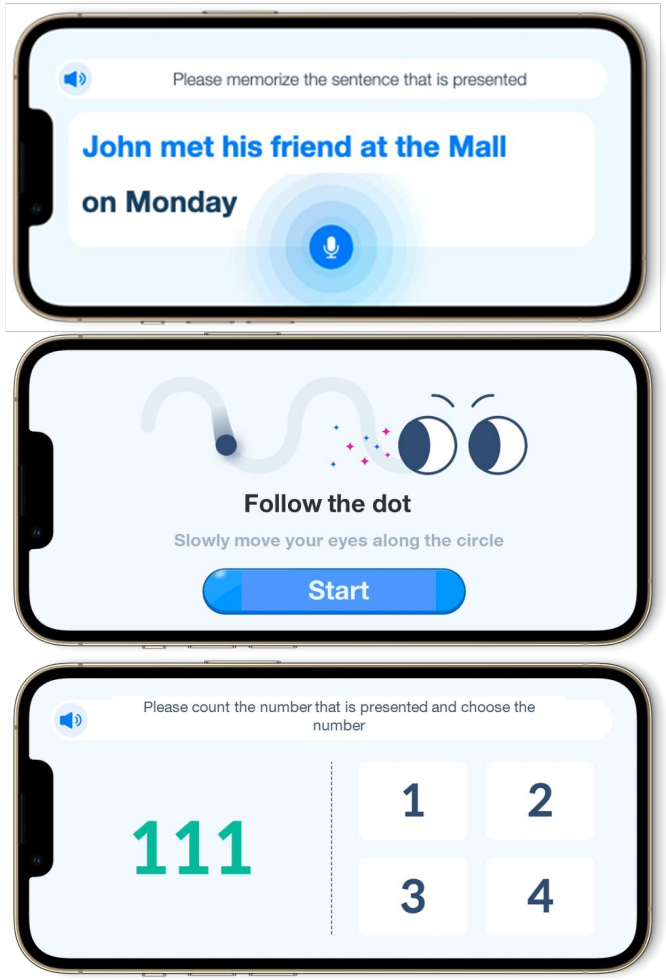
✔ **The more frequently used, the higher the effect is.**



Interim message

- The training for the elderly clearly improved the cognitive function
- The lower the cognitive capacity the subject showed, the higher the effect is
- The more the subject played Alzguard-T, the more the cognitive function improved
- The more the subject participated in the group chat moderated by software robot (Smart masilbang) , the more the cognitive function improved

Conclusion



- AlzGuard raised an optimistic expectation on the collection of data with high quality efficiently
- Biomarker clearly worked – but we want to something more beyond the evident features
- By building and evaluating the data, we confirmed that the data was well collected enough to achieve the high performance on the screening of people in the potential risk of MCI
- AlzGuard-T and Smart Masilbang is working!
- AlzGuard-D leading to AlzGuard-T with the optimal training curriculum

Thank you for your attention!

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HAII visual camp KOREA UNIVERSITY IITP Institute of Information & Communications Technology Planning & Evaluation NRF National Research Foundation of Korea SAMSUNG Samsung Science & Technology Foundation