

Proposal for a session CAA 2026,

" Reframing Cultural Properties Rather than as "Relics of the Past" but as "Objects that Stimulate Modern People's Perception, Sensibility, and Meaning-Making" "

(Cognitive Cultural Property Session in short)

Chosen format of the session: Standard or Other (including an innovative one hour demonstrative session of Mixed Reality gaze/emotion tracking depending on the date of the session)

Session Founders and Organizers:

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a) Background of this session

This proposing session is a continuous one of the session "Cognitive Mind" organized and held at CAA 2025, of which we enforced the session by adding EEG/ERPs components and specialists as founders, for better understanding of body reactions against stimuli and emotional categories.

b) Abstract thinking and sculptures in Jomon Period

The Mind, capable of abstract thinking, is considered a distinctive feature of modern humans, Homo sapiens. Archaeological evidence includes ornaments such as shell beads found in the Skhul Cave in Israel, which may date back to around 100,000 years, as well as the cave paintings of Lascaux in France and Altamira in Spain. Additionally, Paleolithic

figurines such as the Lion Man and Venus figurines are widely known across Europe and the Eurasian continent. While no cave paintings have been discovered from the Jomon periods of the Japanese archipelago, artifacts believed to be stone and clay figures and ornaments have been found, suggesting they are part of a group of *Homo sapiens* that dispersed across the globe. Notably, Jomon clay figures, known as Dogu, a general term for extremely abstracted human-shaped clay products, were consistently present throughout the Jomon period, albeit in varying quantities, but dramatically declined and disappeared during the Yayoi period. Therefore, Dogu can be considered artifacts that narrate the unique cognition of the Jomon period.

In the period when such distinctive characteristics of clay figures (dogū) became prominent, changes were observed in the morphological features of Jōmon pottery. During this time, exemplified by the so-called flame-like pottery, large protrusions and three-dimensional patterns became conspicuous, and many designs and forms of overwhelming presence emerged, exerting a significant influence on modern artists such as Okamoto Taro.

Up to now, no academic discipline has been organized on the methodologies to investigate cultural properties as materials which are "Stimulating Modern People's Perception, Sensibility, and Meaning-Making." Extracting and identifying the attributes of artefacts—representative tangible cultural heritage of the ancient periods— are deeply involved in the perception, sensibility, and meaning-making processes of contemporary viewers.

The organizers of this session devised a simultaneous measurement method, described later, in which viewers of cultural properties provide data for each of the following indices corresponding respectively to perception, sensibility, and meaning-making: fixation points on the object over time, emotional labels selected by the participant, and spontaneous verbal utterances concerning the object. Since these emotional labels and spontaneous utterances are synchronized with the fixation points, adding electroencephalogram (EEG) data enables precise recording and analysis of where the participant was looking, what physiological responses occurred, and whether meaning-making took place.

Methods to extract and distinguish the relationship between these sculpture characteristics and the cognition of modern people, or the commonality and continuity of these characteristics within and beyond regions in the same community (site), are now being investigated as follows.

c) Commonalities of cognitive processes and mind structures

"Cognitive Archaeology, Body Cognition and Evolution of Visuospatial Perception" (2023) [2] illustrated how body perception and spatial sensing might have evolved in humans, which suggests both body perception and spatial sensing have commonalities among human beings.

Matsumoto (2000) [3] used the theory and methods of cognitive archaeology to argue that the mind and body have had developed together in the course of human evolution, and therefore the structure of the mind should be considered to be common to the same extent as the structure of the human body. She also claimed that there was a certain degree of universality in human cognitive processes and cognitive structures, and that the same models and conceptual frameworks could be applied across differences in culture and social structure.

d) VR and MR from instant 3D view to eye fixation experiment with emotion and impression

VR (Virtual Reality) and MR (Mixed Reality) represented a significant advancement by enabling viewers to see and simulate things that are not normally visible. Artefacts converted to 3D can be easily visible by VR/MR equipment, therefore one can obtain instant experience of viewing ancient artifacts.

Microsoft HoloLens2 is capable of capturing the viewer's gaze data using its built-in cameras and sensors. This data includes the 3D coordinates of the fixation point, the direction of the gaze, and the fixation duration (saccades and fixations), serving as indicators of where a person's potential cognition is directed on an object. By projecting the duration of gaze fixation on the surface of the object as color-graded information, it can be visualized as a 3D heatmap.

Furthermore, we connected HoloLens2 and Ten Keys by Bluetooth, which enables sending and receiving signals of simplified participants' emotional labels by pressing keys, synchronized with the fixation points, enabling visualization of 3D emotional maps.

We also make a short duration of spontaneous utterances or speech of the participants on the impression of the objects which are also synchronized with the fixation points, and speech will be translated to text for further analysis using Large Language Models.

e) Measuring cognition using SD Method

As an experimental method for extracting the mental images people have when viewing objects, the Semantic Differential (SD) method is widely used in psychological testing. This method involves providing pairs of simple sensory impression adjectives, such as "beautiful-ugly," for subjects to rate on a scale. The SD method serves as crucial information to analyze

how people perceive objects as stimuli through many simple sensory impression adjectives. A research paper using this method is now published as a proceedings of CAA [1].

f) Reconstructing the Cognition Using Deep Generative Models

After a long period of stagnation, machine learning experienced a major turning point with deep learning for image recognition in 2012. Over the past 12 years, advancements in deep learning models have led to cognition analysis capabilities far exceeding human abilities. Recently, these models have been applied to cognition analysis as part of information psychology. By analyzing sensory impressions of subjects viewing artifacts along with data on these objects, deep cognition models offer new insights.

g) Prediction of Emotional Response Categories Using Event-Related Potentials (ERPs)

Event-related potentials (ERPs), which capture the temporal responses of the brain to visual stimuli, contain features that reflect differences in stimulus categories and cognitive processing, serving as key indicators for emotion classification and semantic comprehension. For visually presented object groups—such as Jōmon pottery and clay figurines—that differ in shape and semantic interpretation, repeated ERP measurements make it possible to construct models that predict the category of emotional responses to stimuli based on electroencephalographic (EEG) data. In July 2025, emotional label measurements were conducted with a total of 306 participants in Japan and Malaysia. Given the observed fact that many participants recorded gaze trajectories associated with a single emotional label, we became confident that extracting ERPs from EEG measurements synchronized with such single emotional labels would enable the development of models capable of predicting emotional response categories [4] [5].

h) The Need for Cultural Property Cognition Studies Session

Cognitive cultural property studies, deeply intertwined with experimental psychology and cognitive information processing, is a crucial field for exploring human psychology and the cognition through archaeological artifacts and sites. However, aside from the presentation proposed by the authors at CAA2024, no relevant research was identified.

While it is impossible to directly investigate the cognition of ancient people, it is considered feasible to reconstruct their cognition and mental images under the assumption of commonality with modern human cognition, which were proposed by Burner and Matsumoto. Therefore, this group of founders and organizers proposes a Cultural Property Cognition Session, as a continuous from one session held in CAA 2025.

- i) Possible investigations and methodologies
 - 3D views of artifacts by VR/MR equipment and investigations on observers' perception
 - VR/MR practices for regional historical education
 - VR/MR exhibition as digital museum
 - Eye tracking and gaze emotional methodologies for cognitive investigations
 - Electroencephalographic (EEG) / Event-Related Potentials (ERPs) studies
 - Any cognition related investigations and methodologies
 - Deep learning models/deep generative models on cognition

References

- 1 Fujita Haruhiro et al. (2025), Analysis of Sensory Impression Factor Structures of Jomon Potteries through a Semantic Differential Method Viewing 3D Models on MR equipment, Proceedings of International Conference on Computer Applications & Quantitative Methods in Archaeology (CAA) 2024. DOI <https://doi.org/10.5281/zenodo.14346272>
- 2 Bruner, E., 2023. Cognitive Archaeology, Body Cognition, and the Evolution of Visuospatial Perception. Elsevier Science & Technology, San Diego, UNITED STATES
- 3 Matsumoto Naoko 2000. Theory and practice of cognitive archaeology, Kyushu Univ. Press
- 4 Sano T., Shi J., Kawabata H. (2024) The differences in essential facial areas for impressions between humans and deep learning models: An eye-tracking and explainable AI approach
- 5 Sano T., Kawabata H. (2024) Neural responses to perceptual and sexual ambiguity in facial images: an ERP and time-frequency analysis