Art and Brain with Kazuo Takiguchi

– Revealing the Meme Structure from the Process of Creating Traditional Crafts –

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A Short Resume of the Presenter

Muneo Kitajima currently works at the Department of Management and Information Systems Engineering, Nagaoka University of Technology. His recently published book "Memory and Action Selection in Human-Machine Interaction" (2016) proposes a unified theory of action selection and development by integrating PDP, Two Minds, and layered structure of human action. The theory provides a comprehensive view of how our brain functionally works in our daily life. His current interest is to understand the implications of the theory to development of skill of adaptive problem solving, the important skill for survival.

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- ***What factors make traditional art what it is?*** This paper attempts to answer this question through an analysis from the cognitive science perspective.
- The subject of the study is **Japanese traditional crafts**. We believe that the process of artwork production is formed as a result of the interaction between *the individual behavioral ecology of the artist* and *the collective behavioral ecology surrounding them*, and attempt to analyze it using a functional brain model.
- **This study aims to elucidate memes that interface the Perceptual, Cognitive, and Motor (PCM) processes that artists employ while creating artworks with the individual and collective behavioral ecologies that are used in these processes.**
- This study focuses on the artwork production process of ***Kazuo Takiguchi***, a leading Japanese ceramic artist. In elucidating the processes, ***Model Human Processor with Realtime Constraints (MHP/RT)***, cognitive architecture that can simulate human behavioral processes by means of PCM processes and Multi-Dimensional Memory Frames (MDMFs) that represent memes, and ***Cognitive Chrono-Ethnography (CCE)***, a survey method to understand the characteristics of behaviors expressed on the basis of these processes are employed.
- ***The CCE results revealed that the collective behavioral ecology, which contains the individual production experience of each artist folded into the individual behavioral ecology of the artist, and the skill acquisition of the production area formed over a long time, enables the artist to unconsciously imagine and meditate on the production process results, working on the production itself and on the firing and glazing process that bring irreversible changes to the production, to predict with accuracy, and to consciously evaluate the actual results.***

Background

- In the modern era, information worldwide is interconnected, and modern educational systems are widespread. Historically, such a situation was unusual. In fact, in the past, each region had its own unique collective behavioral ecology, formed over a long period of time while adapting to the local climate. The generated collective behavioral ecology formed region-specific memes, which have become the basis for individual behavioral ecologies today. ***In other words, the natural and spiritual climates are reflected in the collective behavioral ecology, which in turn is reflected in the individual behavioral ecology through memes.***
- This paper focuses on traditional arts, which are creative activities rooted in the local community and developed as traditions in a collective behavioral ecology, and describe the process by which they were established and the environmental conditions that enabled them to continue. An individual's artistic disposition belongs to their individual behavioral ecology and is expressed through a structured meme that is formed on the brain's parallel distributed memory structure [1] and the activities that utilize them [2].

Purpose

- Therefore, the purpose of this study will be to answer the following research questions:

Research Questions

RQ-1 What does the structured meme look like?
RQ-2 How is it formed?
RQ-3 What are the environmental conditions that allow its formation to continue?
RQ-4 How are the artistic activities performed on it?

At the 0-th order approximation, a person interacts with his or her environment by running an endless cycle of perceiving the external and internal environment through five senses via sensory neurons as parallel processing, and acting to the external environment through body parts via motor neurons as serial processing. As s/he perceives the results of movement of his/her body parts as well as the changes of the external environment as time goes by, the next cycle of Perceptual–Motor should occur. Interneurons in-between the sensory neurons and motor neurons convert the input patterns to the output patterns – these constitute a Perceptual–Cognitive–Motor (PCM) process.

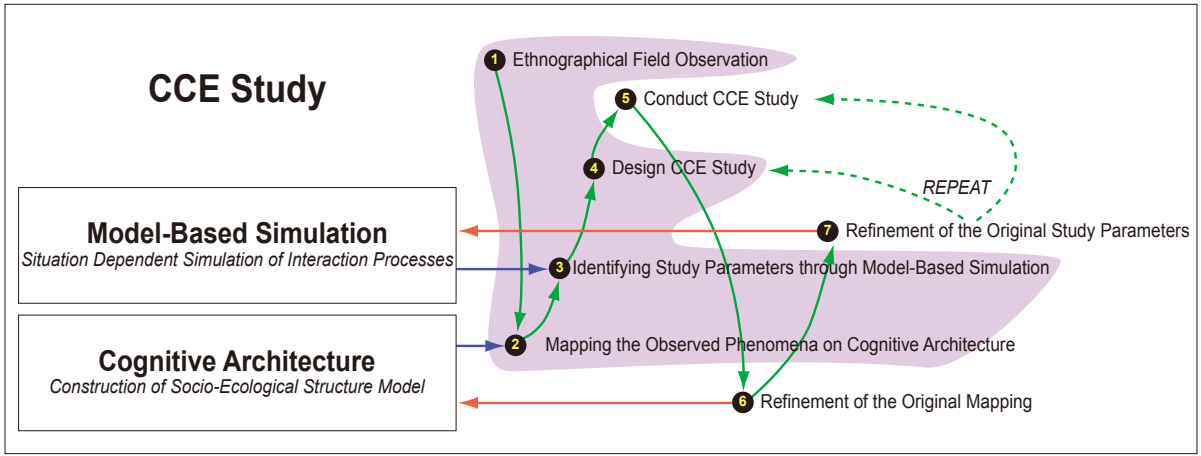
Model Human Processor with Real-time Constraints (MHP/RT)

- Starting from the basic PCM cycle, we constructed a comprehensive theory of action selection and memory, MHP/RT, providing a basis for constructing any models for users interacting with ever-changing environment.
- MHP/RT's purpose is to implement at a higher level the following facts on the assumption that the processing involved in action selection is truly dynamic interaction that evolves in the irreversible time dimension.
  1. *The fundamental processing mechanism of brain is **Parallel Distributed Processing (PDP)** [1];*
  2. *Human behavior emerges as the results of competition of the dual processes of **System 2**, slow conscious processes for deliberate reasoning with feedback control, and **System 1**, fast unconscious processes for intuitive reaction with feedforward control for connecting perception and motor movements, called **Two Minds** [3];*
  3. *Human behavior is organized under **happiness goals** [4].*

Cognitive Chrono-Ethnography (CCE)

- MHP/RT accompanies behavioral study methodology, CCE [5] to be used to utilize, validate, and/or refine MHP/RT.
- Equipped with MHP/RT, how can we study people's behaviors, characterized by Two Minds working dynamically along the time dimension? We came up with a solution, called CCE.
- CCE combines the following three concepts.
  1. ***Cognitive** declares that CCE deals with interactions between consciousness and unconsciousness in the PCM cycles.*
  2. ***Chrono(-logy)** is about time ranging from ~100 msec to days, months, and years, and CCE focuses on such time ranges.*
  3. ***Ethnography** indicates that CCE takes ethnographical observations as the concrete study method because in daily life people's Two Minds tends to re-use experientially effective behavioral patterns, called "bias."*

≪ CCE Provides Answers to the RQs. ≫



Step 1: Ethnographical Field Observation

Use the basic ethnographical investigation method to clarify the outline of the structure of social ecology that underlies the subject to study.

Step 2: Mapping on Cognitive Architecture

With reference to the behavioral characteristics of people which have been made clear so far and MHP/RT, consider what kind of characteristic elements of human behavior are involved in the investigation result in Step 1.

Step 3: Structural Modeling

Based on the consideration of Steps 1 and 2, construct an initial simple model with the constituent elements of activated memories, i.e., meme, and the characteristic PCM processing to represent the nature of the ecology of the study space.

Step 4: Design a CCE Study

Based on the simple ecological model, identify a set of typical behavioral characteristics from a variety of people making up the group to be studied. Then formulate screening criteria of elite monitors who represent a certain combination of the behavioral characteristics, and define ecological survey methods for them.

Step 5: Conduct CCE Study

Select elite monitors and conduct an ethnographical field observation.

Step 6: Refinement of the Original Mapping

Check the results of Step 5 against the results of Step 2 for appropriateness of the mapping. If inappropriate, back to (2) and redo from there.

Step 7: Refinement of the Original Study Parameters

If the result of Step 5 is unsatisfactory, go back to Step 4 and re-design and conduct a revised CCE study, otherwise go back to (3) to redo the model-based simulation with a set of refined parameters.

CCE Step 1 (This Step Includes CCE Steps 4 and 5 in This Study)

The first step of CCE is conducted in two stages for the purpose of identifying characteristics of Japanese arts. In a typical CCE, the researcher actually goes to the site and describes what is happening there. On the other hand, there are many findings on Japanese traditional arts. Therefore, in CCE-Step 1-1, these findings are summarized in the form of the structure of a collective behavioral ecology. This will address RQ-2 and RQ-3.

Step 1-1

- The collective memes that have been nurtured as a Japanese tradition has become effective in the acquisition of individual skills [RQ-3].
- Individual behavioral ecology can be viewed as action-level, behavior-level, and cultural-level memes. The development of perception and movement leads to the development of the action and behavior level memes. The development process is unique to each individual's developmental environment and is often acquired through trial and error based on "imitation."
- In the traditional arts, memes are acquired and utilized in the creative activities of the entire field, functioning as a cyclical system of inheritance and continuity. This defines the characteristics of the collective behavioral ecology of the group [RQ-2 and RQ-3].
- In this study, "ceramics" is taken up as a traditional Japanese art form.
- It is the art of making ceramics by molding clay and firing it at high temperatures. In ceramics, the process consists of imaging the desired form of the object, molding the clay base into the desired form, applying a glassy coating, heating it in a kiln to increase strength, hardening, and fixing the form.

Step 1-2

- This step takes the ceramics artist as a super elite sample, a singularity in the individual behavioral ecology of ceramics activity, and summarizes his ceramics activity as a structure of individual behavioral ecology [RQ-2 and RQ-3].
- The super elite sample is the ceramic artist ***Kazuo Takiguchi***.
  - *He is one of the leading contemporary ceramic artists in Japan, born in 1953 as the son of a tableware wholesaler in Gojozaka, a traditional ceramic production area in Kyoto.*
  - *He has been creating ceramics mainly in Kyoto, the center of traditional Japanese art, for a long time, sublimating imagination and meditation activities in ceramic production, and practicing complex perceptual–motor mappings at a level that cannot be reached by ordinary people.*
  - *He has produced two very different groups of works, **YUDAI** and **MUDAI**, both extremely different in appearance.*
- We observed and interviewed him during the process of ceramic production. The results are shown on Slide 7, concerning the working process of **YUDAI** and **MUDAI** with examples of each of these works.

	YUDAI	MUDAI
Artwork	 (a)	 (b)

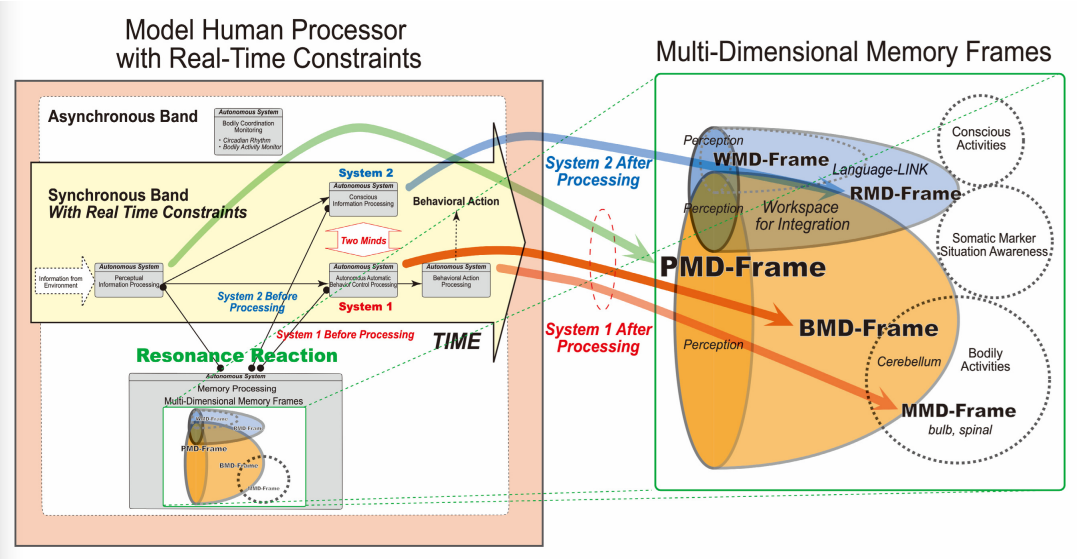
Work Step	For YUDAI	For MUDAI
Master-Planning	∗ Decide on the rough image of the work • Decide on the specific title of the work • Decide on the image of the work that adequately represents the title • Decide on the number of parts that comprise the work ∗ Decide on the material / Decide on the size	∗ Decide on the rough image of the work ∗ Decide on the material / Decide on the size
Natural-Modeling		• Form the overall shape of a plate-like material by effectively utilizing the gravity field
Modeling	• Create the model you have in mind (if the modeling consists of multiple parts, make that number of parts) with the consideration that it will not break during unglazed-firing ∗ Consider a plan for unglazed-firing	• Modify the overall shape of the foundation according to one's own inspiration to create the final form ∗ Consider a plan for unglazed-firing
Unglazed-Firing	∗ Fire in a kiln according to the unglazed firing plan	∗ Fire in a kiln according to the unglazed firing plan
⇒ *End*		
Coloring *repeat*	• Select a glaze that matches the finished image of the work • Glaze it • Considering glazed firing plan	
Glazed-Firing	• Fire in kiln according to glaze firing plan	
⇒ *End*		
Glazing *repeat*	∗ Choose a glaze that is matched to the surface texture of the piece ∗ Glaze ∗ Consider a firing plan that suits the glaze	∗ Choose a glaze that is matched to the surface texture of the piece ∗ Glaze ∗ Consider a firing plan that suits the glaze
Main-Firing	∗ Fire based on the firing plan	∗ Fire based on the firing plan
⇒ *End*		

In this step, the results of the CCE-Step 1 survey are reviewed from the perspective of individual behavioral ecology. We will perform brain simulations assuming the action-level, behavior-level, and culture-level memes on the cognitive architecture to identify the way the brain works, in a way that best explains the results of the survey. That is, we identify critical parameters that characterize the behavioral ecology of individuals. Brain simulations are based on the cognitive architecture MHP/RT [5, 6].

- **Slide 9:** Two Components of MHP/RT
- **Slide 10:** Four Operation Modes and Four Processing Modes of MHP/RT
- **Slide 11:** Simulation of Kazuo Takiguchi's Processes based on MHP/RT's Four Operation Modes and Four Processing Modes

- **The first component (left) comprises cyclic PCM processes. They execute a series of events in synchronous with changes in the external environment.** The parallel distributed processing [1] for realizing these PCM processes is implemented as hierarchically organized bands introduced by Newell [7, Figure 3-3]. These bands are characterized by characteristic operation times, which are defined by associating relative times with individual PCM processes. Events occur by connecting what happens in a band to what happens in its adjacent band *non-linearly*. A mechanism is required to connect the events; MHP/RT suggests that this connection is provided by *the resonance mechanism* via the MDMFs, shown by •—• in the figure.

- **The second component (right) is the autonomous memory system consisting of five MDMFs, which are Perception, Motion, Behavior, Relation, and Word MDMFs.** The MDMFs store information associated with the corresponding autonomous processes defined in the PCM processes. The MDMFs are subservient to the PCM processes because they do not exist unless the PCM processes do.



Four Operation Modes of MHP/RT

Synchronous Modes

Mode 1: System 1 driven mode

A single set of perceptual stimuli initiate feedforward processes at the B-(iological) and C-(ognitive) bands to act with occasional feedback from an upper band, i.e., C-, R-(ational), or S-(ocial) bands.

Mode 2: System 2 driven mode

A single set of perceptual stimuli initiate a feedback process at the C-band, and upon completion of the conscious action selection, the unconscious automatic feedforward process is activated at the B- and C-bands for action.

Asynchronous Modes

Mode 3: In-phase autonomous activity mode

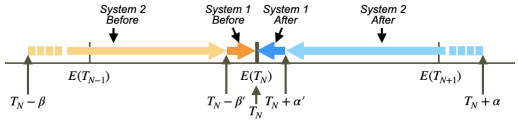
A set of perceptual stimuli initiate feedforward processes at the B- and C-bands with one and another intertwined occasional feedback processes from an upper band, i.e., C-, R-, or S-bands.

Mode 4: Heterophasic autonomous activity mode

Multiple threads of perceptual stimuli initiate respective feedforward processes at the B- and C-bands, some with no feedback and others with feedback from the upper bands, i.e., C-, R-, or S-bands.

Four Processing Modes of MHP/RT

The experience associated with an individual's activity is characterized by a series of events that are consciously recognized serially. Let $E(T_N)$ denote the event that occurred at time T_N. The experience is then defined as a series of events along the timeline, " $\cdots \rightarrow E(T_{N-1}) \rightarrow E(T_N) \rightarrow E(T_{N+1}) \rightarrow \cdots$ ". Considering the way System 1 and System 2 are involved in individual events, four processing modes can be defined:



- **System-2-Before-Event-Mode**: In the time range of $T - \beta \le t < T - \beta'$, MHP/RT plans for future events to occur. There is enough time to think carefully.
- **System-1-Before-Event-Mode**: In $T - \beta' \le t < T$, the action selections smoothly generate the immediate event.
- **System-1-After-Event-Mode**: In $T < t \le T + \alpha'$, to perform better for the same event in the future, the connection between the incoming perceptual information and the output motor content is adjusted unconsciously.
- **System-2-After-Event-Mode**: In $T + \alpha' < t \le T + \alpha$, the event is reflected upon. The results are stored and used in the next System-2-Before-Event-Mode before a similar event occurs.

Outline of MHP/RT Simulation for Work-Step 1~8

1. **Master-Planning:** Performed in the Operation Mode 2; Four Processing Modes are organized as shown in (I).
2. **Natural-Modeling for MUDAI:** Performed in the Operation Mode 1; Four Processing Modes are organized as shown in (II), relatively long time is needed before getting feedback, indicated by ————-//————- α.
3. **Modeling:** Performed in the Operation Mode 1; Four Processing Modes are organized as shown in (III), with repetition until satisfactory model is obtained.
4. **Unglazed-Firing:** Executed as a process according to (II).
5. **Coloring for YUDAI:** Executed as a process according to (III).
6. **Glazed-Firing for YUDAI:** Executed as a process according to (II).
7. **Glazing:** Executed as a process according to (III).
8. **Main-Firing:** Executed as a process according to (II).

(I) Each Step of Master-Planning in Mode 2

(β —— β' –∗– α' —— α) *Repeat*

- β: Consciously clarify the policy for updating the current idea.
- β': Spread activation in the MDMFs.
- $*$: Decide on an update for the current idea.
- α': Organize activation in the MDMFs.
- α: Consciously evaluate the updated idea.

(II) Natural-Modeling for MUDAI in Mode 1′

β – β' –∗– α' ————-//————- α

- β: Clarify the final modeling of the plate-like material and a candidate is placed in the P-MDMF.
- β': Spread activation in the MDMFs.
- $*$: Make a decision with the modeling and carry it out.
- α': Organize activation in the MDMFs.
- α: Evaluate the decision consciously.

(III) Modeling in Mode 1′′

(β – β' ——//——∗——//—— α'– α) *Repeat*

- β: Consciously think of the finished form of modeling.
- β': Spread activation in the MDMFs.
- $*$: Create a form as a candidate for the finished form of modeling.
- α': Organize activation in the MDMFs.
- α: Imagine the results of unglazed firing for the finished form of modeling.

Based on the considerations in CCE-Step 1 and 2, we can construct a simplified individual behavioral ecological model of the surveyed space that explains the differences among people acting in the collective behavioral ecology of that space.

- The results of the simulation by MHP/RT for each of the ceramic steps shown in CCE-Step 2, we can see that the unconscious spreading activation in the MDMFs by System 1 affects the performance of each process.
- Except for Master-Planning, MHP/RT operates in Mode 1. The following patterns characterize the way of operation.

Operation Patterns

Mode 1''
A: ($\beta - \beta' \text{ ——//——}*\text{——//—— } \alpha' - \alpha$) *Repeat*

Mode 1'
B: $\beta - \beta' - * - \alpha' \text{ ————-//————- } \alpha$

- Similarity between the patterns is the upcoming event $*$ is consciously processed by System 2 and the event that has occurred is consciously evaluated by System 2.
- In doing so, the part of the $M \otimes N$ mapping within the MDMFs (mapping of M-dimensional perceptual input to N-dimensional motor output) that was active during the period of (β, α) is made consciously available for future processing by System 2 at α.
- The contents of the MDMFs to be integrated at α will differ depending on where the event $*$ is located in relation to β, β', α' and α.
- Nevertheless, the contents that diverged during (β, $*$) converge during ($*$, α), and the whole is organically related and integrated.

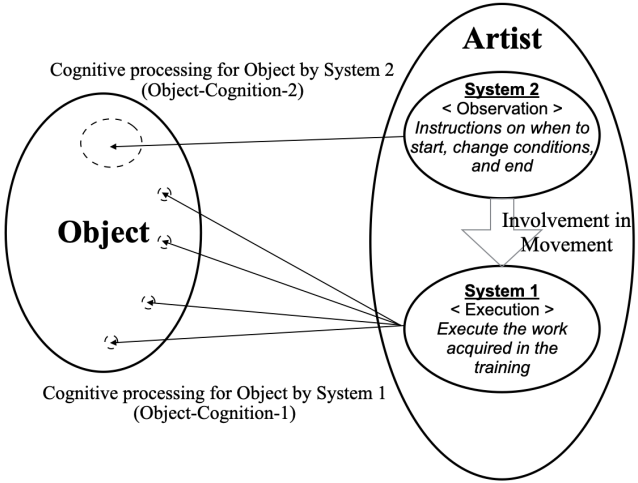
The characteristics of the way of operation can be summarized as follows. In Pattern A, processing by System 1 is performed for a long time before and after the event. In Pattern B, processing by System 2 is performed after a long time after the event. In Pattern A, System 1 executes imaginative and meditative activities by activating a variety of possible pathways of $M \otimes N$ mappings within the MDMFs, constructed through years of experience. How divergence and convergence are executed over time influences the ceramic activity.

Two operating patterns, Patterns A and B, were identified in CCE Step 3. They characterize how the MDMFs should be used in the respective steps. By checking that these patterns match the actually observed ceramic activity of Kazuo Takiguchi, RQ-1 and RQ-4 will be addressed.

- **Understanding When to Do Critical Actions:** Based on the results of the observations and interviews of Kazuo Takiguchi shown on Slide 7, it was evident that the appropriate timings for starting, change in condition, and ending were applied in each step; these were acquired empirically through repeated production activities.
- **Understanding What to Do at the Critical Timings:** It was possible to identify the actually applied work conditions that should produce the desired results by memorizing the points indicating the changes within the perceivable range and their superficial changes through observation of the process of work, and comparing what has been memorized with the results after the work.

Hierarchical mapping structure characterized by $M \otimes N$ mapping

- What is happening in these steps is illustrated in the figure on the right.
- The left side of the figure shows the manipulated object, **O**, and the right side shows the artist, **A**, which is Kazuo Takiguchi.
- **A** executes the following processes:
  1. Observe **O** under consciousness (OBJECT-Cognition- 2), and
     1) become aware of the timing to start the execution of work,
     2) become aware of the conditions for changing and updating the work content that has been started, and
     3) become aware of the conditions for ending the work.
     This is executed by System 2.
  2. Execute the contents that have been made conscious by activating the work sequences that have been acquired through training. Execution is done by perceiving the state of **O** with the five senses (OBJECT-Cognition-1) and applying the appropriate exercise to **O**. This is done by System 1.
- The work is stored as an experience of System 1 and System 2, and influences future work.



- The way in which each work step is carried out is well aligned with the four processing modes of the MHP/RT, each of which is carried out during the periods of $[\beta, \beta')$, $[\beta', *)$, $(*, \alpha']$, and $(\alpha', \alpha]$.
- Considering the activities performed in the respective four periods, they are represented by the following two hierarchical mapping structures.

Pattern A: Hierarchical Mapping Structure of Transformation caused by OBJECT Manipulation

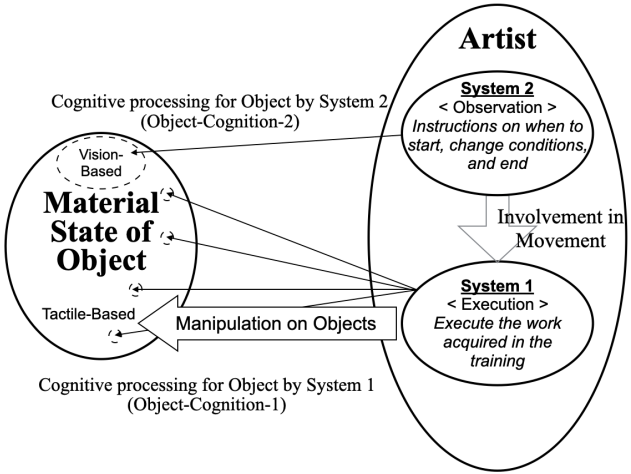
- When an operation is applied to **O** (Object), it changes according to its contents. This is related to the steps of Modeling, Coloring, and Glazing.
- What is happening in these steps is illustrated in the figure on the right.
  1. The current state of **O** is mainly perceived visually (with the help of tactile sense), and the immediate aim is to reach the final goal and the contents of operations to reach it are selected and decided by System 2 through the experience accumulated thus far (OBJECT-Cognition-2).
  2. Based on this decision, **A** (Artist) perceives the state of **O** mainly through the tactile sense and perceives the progress of the operation by System 1 (OBJECT-Cognition-1) while moving his limbs to interact with **O** to change it.
  3. Once the immediate goal is achieved, the next goal is set and this process is repeated until the final goal is achieved.
- The way these work processes proceed is well matched to Pattern A.

Steps performed in Pattern A

- Modeling
- Coloring for YUDAI
- Glazing

Mode 1''

A: ($\beta - \beta'$ ——//——*——//—— $\alpha' - \alpha$) *Repeat*



Pattern B: Hierarchical Mapping Structure of Transformation caused by Environmental Change

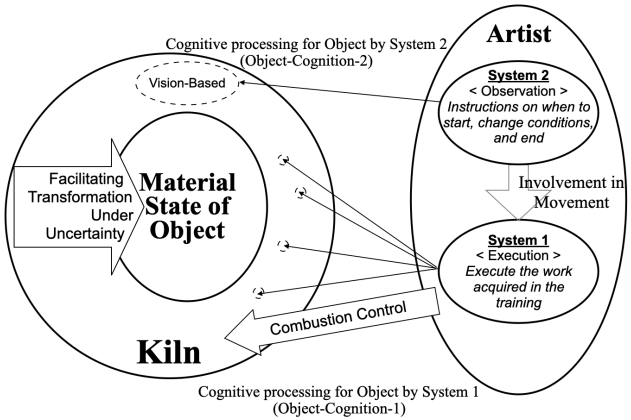
- In the steps to perform the firing, Natural-Modeling and Unglazed-, Glazed, and Main-Firing, the objects created due to the direct transformation of the objects in the preceding steps are irreversibly transformed and fixed by the application of gravitational field or firing environment in the kiln.
- What is happening in these steps is illustrated in the figure on the right.
  1. The current state of **O** is perceived visually, and the firing parameters that realize the firing environment in the kiln to reach the final goal are selected and determined by System 2 using the experience accumulated (OBJECT-Cognition-2).
  2. Based on this decision, the kiln is adjusted for firing and firing is started.
  3. Firing is an unpredictable and uncertain process. During firing, the state of the kiln is recognized by System 1 via all five senses (OBJECT-Cognition-1) and integrated with previous experiences as a new experience.
- This way of proceeding with the work process is well matched with Pattern B.

Steps performed in Pattern B

- Natural-Modeling for MUDAI
- Unglazed-Firing
- Glazed-Firing
- Main-Firing

Mode 1′

B: $\beta - \beta' - * - \alpha' - /\!/ - \alpha$



- This study focused on ceramics, a traditional Japanese craft, and investigated the memes that make it a traditional craft by conducting a CCE survey with a ceramist as a super-elite monitor. In ceramics, the manipulation of objects that are malleable and whose properties change with time and the setting of firing conditions that produce irreversible physical and chemical changes in the clay and glaze, are performed.
- In both cases, the initial image is placed in the P-MDMF and the activity is propagated in the MDMFs, which are constructed with extensive experience as memes, to simulate whether or not a work that matches the final image is obtained.
- When time constraints are strong, the richness of the MDMFs related to System 1 can be an effective help. The quality of the memory is important for the experiential content during the training period. Tradition can be understood as a generic term referring to the results of improving the content quality of one's training over a long period of time.
- In the West, there is a strong emphasis on logical thinking by System 2, seeking eternity and finding laws in nature. Based on this way of thinking, they have discovered objectivity, the golden ratio, perspective, and so on, and have applied them to their creations. In modern times, this attitude can be seen in the cubism of Picasso, for example.
- On the other hand, in Japan, as revealed in this study, there is a tendency to devise pseudo-expressive methods to express what one truly wants to express, based on the experiential perception obtained from interacting with the natural world. This can be seen in ink paintings and ukiyoe.

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