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Formal Concept Analysis of Musicians' Awareness for Musical Expression

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ABSTRACT

This paper proposes a logical framework that visualizes musicians' conceptual structures that are acquired in skill communication processes for musical expression as rhetoric. Generally, these conceptual structures are difficult to show difference between experts and beginners. So, we first carry out a theoretical analysis of musicians' awareness for musical expression using Channel theory and Formal Concept Analysis (FCA). Then, we propose a representation that shows the level of musicians' skills of musical expression. Finally, we discussed about hierarchy of musicians' conceptual structure.

I. INTRODUCTION

In the field of art and traditional craftwork, passing experts' skill and knowledge about art down the generations is important, and visualization of them as a mean of expression is gaining attention. On conveying musical interpretation, there are cases where it leads to a better interaction by using metaphorical expression instead of using direct expression of the sound based on Loudness, Pitch, and Timbre (Motoyoshi, 2006). In these interactions, communicant's concept structure is preserved to some extent when communicated.

This interaction gives a communicant some choices of metaphorical expressions as far as communicant's concept structures are transmitted effectively. Furthermore, this interaction without using direct expressions allows communicatee putting original interpretations on communicant's concept structures. In addition, using metaphor frees communicants from perfect verbalization. On the contrary, communicatee may not benefit from these merits due to their age or difference of cultural background; communicants need guidelines for selecting rhetoric. To establish this guideline for instructors and managers, constructing mathematical framework that describe musical interpretation via rhetoric is one solution. For description of this communication process of concept structure, we consider that qualitative information theory instead of Shannon's quantitative information theory is well-suited. For this reason, we introduce channel theory (Barwise, 1997, Shimojima, 1998) as a mathematical framework which is being broadly adopted in the fields such as Abstract Design Theory (Kakuda, 2001), Knowledge Sharing using ontology (Kent, 2000), and description of contextual communication in play environment (Kawakami, 2004, Motoyoshi, 2004),. On defining classifications that represents communicants' and communities' conceptual structure, guideline of representation has not been established.

Thus, in this paper, we carried out a structural analysis of a rhetoric generation process used in the scene of musical teaching that we collected in our earlier study in a cognitive semantic approach. Based on this structural analysis, we proposed a method to describe generation process of communicant's internal representation based on classifications and Formal Concept Analysis.

II. Understanding process of rhetoric

In this section, we state about meaning structure of the rhetoric cognition process. ``affective meaning," ``categorical meaning," and ``script meaning" are the three representative semantic structure that support process of rhetoric (Kusumi, 1994).

A. Affective meaning

In similes, for instance ``feeling is a swamp," there are similar characteristics such as ``deep and gunky" in between the subject ``feeling" and the simile ``swamp." The ``affective meaning" supports the similarity.

On the other hand, synesthetic rhetoric is a representation that the subject and the modificand belongs to a different sense modality. For instance, in rhetoric ``soft voice," communicant uses ``soft" which is a word of tactile sensibility as a word that is related to auditory sensibility. In this case, affective meaning is converted from field of tactile sensibility from auditory sensibility.

B. Categorical meaning

In the rhetoric ``feeling is a swamp," ``feeling" and ``swamp" belongs to abstract concept and geographical concept respectively. Unlike ``affective meaning," there is no similarity in-between the two concept. The source of this insimilarity is called ``categorical meaning." Furthermore, japanese rhetoric ``hana-mi (flower viewing)" is a rhetoric based on the hierarchical relationship of category; the word ``hana (flower)" which is a word of higher level indicates ``cherry blossom" which is a typical instance (in a japanese sense) of a lower level. On the contrary, in rhetoric ``Man shall not live by bread alone," typical instance ``bread" indicates the word ``food" of higher category. Moreover, there are ad-hoc categorical meaning in addition to categories of hierarchical relationship. In the rhetoric ``feeling is a swamp," both ``feeling" and ``swamp" belongs to a same category ``thick thing;" this two words cannot be related by a dictionary-like sense, though communicant relates these two

on a case-by-case basis in order to support similarity of ``feeling'' and ``swamp.''

C. Script meaning

``Little red riding-hood'' indicates ``a girl warring a red riding-hood.'' There is, however, no similarity in-between ``girl'' and ``red riding-hood;'' the two words place reliance on spacial adjacency. Furthermore, there are words that place reliance on temporal adjacency such as the phrase ``tip one's cup'' indicates ``have a drink.'' These adjacency are recognized by generalizing and abstracting daily activities. These knowledge about events that are repeated usually are called ``script,'' and meanings that are constructed by scripts as a basic unit is called ``script meaning'' (Kusumi, 1994).

III. Structural analysis of rhetoric used in communication process of musical interpretation

In this section, we state about meaning structure analysis of the rhetoric used in communication process of musical interpretation collected by case study.

D. Communication of both Motor-Acoustic Representation: like you scoop a ``Yu-ba''

Affective meaning :

If a communicant senses a resemblance in-bewteen tone to be described and ``thinness'' of ``Yu-ba,'' ``a series of weak sounds'' is established as affective meaning. In this case, this meaning structure supports the rhetoric that intends Acoustic Representations.

Categorical meaning

For example, ``Yu-ba'' is selected from ad-hoc category ``weak objects'' as a modifier, when communicant captures a characteristics of sound ``weak.'' In this case, this structure supports the rhetoric that intends Acoustic Representations.

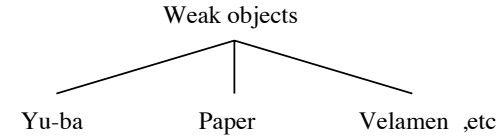

Figure 1. Hierarchical Structure of Ad-hoc Category

Script meaning

The communicant can links the motion ``grasp a bow without much pressure'' with the motion ``scoop Yu-ba'' based on knowledge of temporal adjacency relationship from real experiences ``nudge aside with chopsticks.'' This case shows that motor representation is rhetoric's communication subject, constitution of script from knowledge and experience plays a important role of rhetoric understanding.

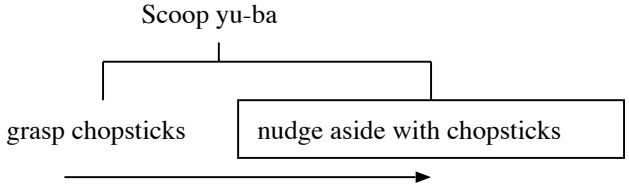

Figure 2. Script meaning of scoop a "Yu-ba"

Meaning structures and Communication Subjects

Structural analysis of the rhetoric shows that there may be multiple meaning structures in single rhetoric. These multiple meaning structures means that a communication content may lead to indication of multiple internal representation. Because of variations of internal representation, the communicant can interpret a rhetoric variedly.

Furthermore, we have found suggestions that selection of script meaning contributes to communication of Motor Representation. If the communicant receives multiple meaning structures at the same time, he can interpret a rhetoric which indicates multiple internal representations.

IV. Development into a mathematical framework

In this section, we state about mathematical framework of the communicant's rhetoric generation processes from internal representations based on structural analysis. The classifications and dual invariant in Channel Theory are used in representations of the communicant's internal represent and rhetoric.

E. Internal representation of the communicant

The classifications which signify the acoustic and motor representation of communicant are defined as follows.

T_M : Classification of ``Motor Representation''
$tok(T_M)$: m_i A set of motion parts
$typ(T_M)$: M_i A set of motions
$m_i \mid = M_i$: motion parts m_i perform motions M_i
T_A : Classification of ``Acoustic Representation''
$tok(T_A)$: a_i A set of musical notes
$typ(T_A)$: A_i A set of Acoustic Representations
$a_i \mid = A_i$: Acoustic representations A_i correspond to musical notes a_i

$typ(T_M)$
M_1 : with a flick of the wrist
M_2 : using bow without much pressure
M_3 : vibrato slowly
$tok(T_M)$
m_1 : right arm
m_2 : left arm
$typ(T_A)$
A_1 : thin sound
A_2 : weak sound
A_3 : height tone
A_4 : without accent
$tok(T_A)$

a_1 : musical notes
a_2 : musical notes

The communicant envisage integrated internal representation from acoustic representations and motor representations. This process is expressed as sum of classifications T_M and T_A as T_S.

T_S : Classification of ``Internal Representation''
$tok(T_S)$: s_{jk} A set of (motion parts, notes)
$typ(T_S)$: S_i A set of rhetoric
$s_{jk} \mid = S_i$: s_{jk} is represented by rhetoric S_i

The classifications by Chu-maps are shown in **Figure 3-5**.

tok(T_M) \ typ(T_m)	M1	M2	M3
m1	1	1	0
m2	0	0	1

Figure 4. A description of "motor representation" by Chu-maps

tok(T_A) \ typ(T_A)	A1	A2	A3	A4
a1	1	1	1	1
a2	1	1	0	1

Figure 5. A description of "acoustic representation" by Chu-maps

tok(T_S) \ typ(T_S)	S1	S2	S3	S4	S5	S6	S7
s11	1	1	0	1	1	1	1
s12	1	1	0	1	1	0	1
s21	0	0	1	1	1	1	1
s22	0	0	1	1	1	0	1

Figure 6. A description of "internal representation" by Chu-maps

F. Meaning structure and dual invariant

In Channel Theory, dual invariant $J = \langle A, R \rangle$ are defined in the classificaion (Barwise, 1997). \$A\$ are the subset of toks and R are the binary relations of typs. In the classification T_S showed in **Figure 5**, we can set the binary relation $S_1 R_1 S_2$ by selecting subsets $A = \{s_{11}, s_{12}\}$. We find that this dual invariant $J = \langle A, R \rangle$ correspond to meaning structures.

For example, the binary relation $S_1 R_1 S_2$ can be interpreted as integrating two script meanings ``with a flick of the wrist'' ``using bow without much pressure.'' The communicant can image the some motions such as ``scoop'' or ``stroke'' from this binary relation. Additionally, he can image some objects such as ``paper'' or ``Yu-ba'' from the binary relation $S_4 R_2 S_5 R_2 S_7$ interpreting as integration by categorical meaning. The Quotient classification A / J_i using these binary relation R_i are the classification representing rhetoric. The binary relations are shown in Figure 7.

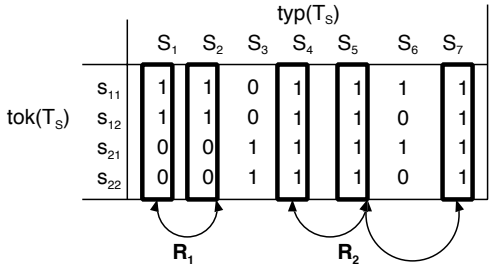

Figure 8. Binary relations in the classification

V. Formal Concept Analysis

We show the concept lattice (Suzuki, 2007) of the internal representation of communicant in Figure 8, which are determined by relating toks to the objects and typs to the attributes. S_4, S_5, S_7 combined by R_2 have binary relations with all toks of classification T_S and are located in the top layer of concept lattice. On the other hand, S_1, S_2 combined by R_1 have binary relations with only s_{11}, s_{12} of classification T_S and are located in the 3rd layer of concept lattice. It shows that rhetoric "Yu-ba" matching to S_4, S_5, S_7 means the playing style achieved by arms, and "Scoop" matching to S_1, S_2 means achieved by only right arm. Thus, concept lattice have possibility of showing the indicated range of each word in rhetoric

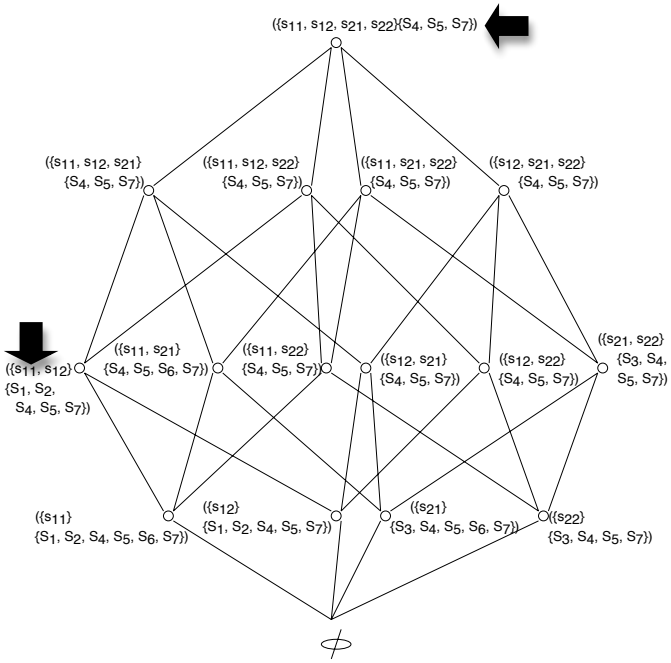

Figure 8. Concept lattice of the internal representation

For example, when taking a notice to only movement of left arm, a communicant should choose the appropriate expression matching to S_3, S_4, S_5, S_7. Communicants who have good skill of musical expressions, can use the good rhetoric which indicates appropriate area of scores, movement, etc.

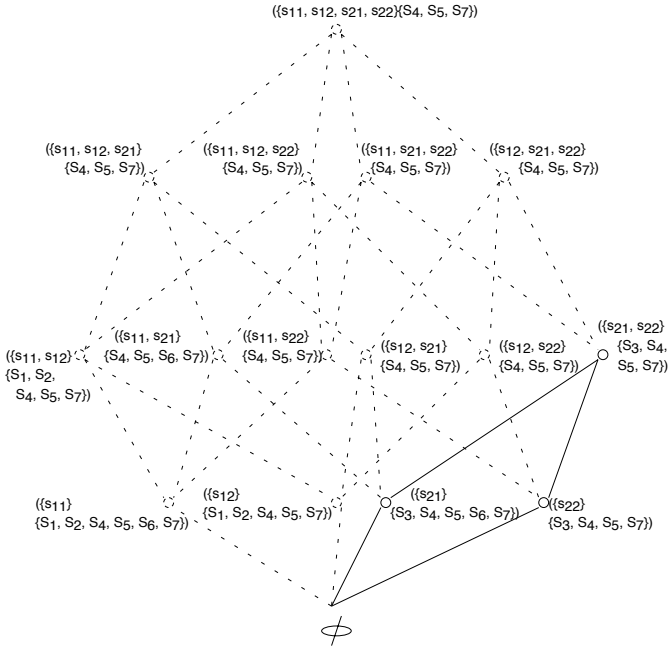

Figure 9. Concept lattice when taking a notice to only movement of left hand

VI. Discussion and Conclusions

In this paper, we focused on metaphors used in communication of musical interpretation, and first we analyzed their semantic structure. As a result, we found that a single rhetoric may have multiple semantic structures. These multiple meaning structures means that a communication content may lead to indication of multiple internal representations. Furthermore, we have found suggestions that selection of script meaning contributes to communication of motor representations. In addition, we attempted to describe these interpretation process of rhetoric based on channel theoretic mathematical framework. As a result, we have found suggestions that the process from communicant's internal representation to metaphor may be represented by classifications, informorphism.

Here, we related meaning structure of metaphor with binary relation R of dual invariant. Next, we discussed about the method of visualizing hierarchical relationship of rhetoric via hierarchization of dual invariant based on the number of tokens in the classification. Moreover, we adopt Formal Concept Analysis, which is a method that is useful to carry out a detailed analysis of patterns and processes of thoughts for the visualization of hierarchical relationship. From result of the analysis, we find that concept lattice shows the indicating area of rhetoric. We can make a judgment about that rhetoric is good and wrong.

Hereafter, we look forward to representing qualitative communication process in-between communicant and communicatee based on information channel by representing generation process of the communicatee's internal representations.

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