Proposal for Analysis of Likes and Dislikes about Musical Instrument Sounds

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Abstract When children visit a musical instrument museum and view the exhibits, listening to the sounds with headsets, even those who are impressed tend to forget what they have seen once the excursion ends. To make the museum visits fruitful for them, I think that children's first impressions of the sounds are important. Analysis of such personal impressions helps make the musical instruments viewed memorable for children. In this paper, I would like to propose analysis of likes and dislike about musical instrument sounds. When children retrieve the museum databases, if the user interface is equipped with such a sound preference analysis function, it would make the data retrieval interesting. I think a conjoint analysis is suitable for the preference analysis. In the paper, I shall discuss how to apply the conjoint analysis to musical instrument sounds. In addition, as a user interface for respondents in a conjoint analysis, the bird-eye tool which I have developed is proposed.

Keyword musical instrument, museum, conjoint analysis, preference tendency, Gunji's systematics, bird-eye tool.

1. Introduction

I have been researching effective musical instrument museum usage for children from ages seven to 11 years. When children visit a museum and view the exhibits, even those who are impressed tend to forget what they have seen once the excursion ends. To facilitate the use of museum exhibits for educational purposes and enrich children's experiences, museum curators make various efforts, including developing multimedia databases and virtual museums on the Web.

One of my areas of particular interest is capturing children's responses to different cultures. It is the case that many people from a Western culture are familiar with Western/European music idioms and sounds, but not particularly familiar with Eastern/Asian idioms and sounds. An interesting study would be on ways of teaching these differences at an early age, by gauging young children's reactions to different musical cultures. A more ethnographic study might be to determine how early in life music cultures are embedded within a child's likes/dislikes.

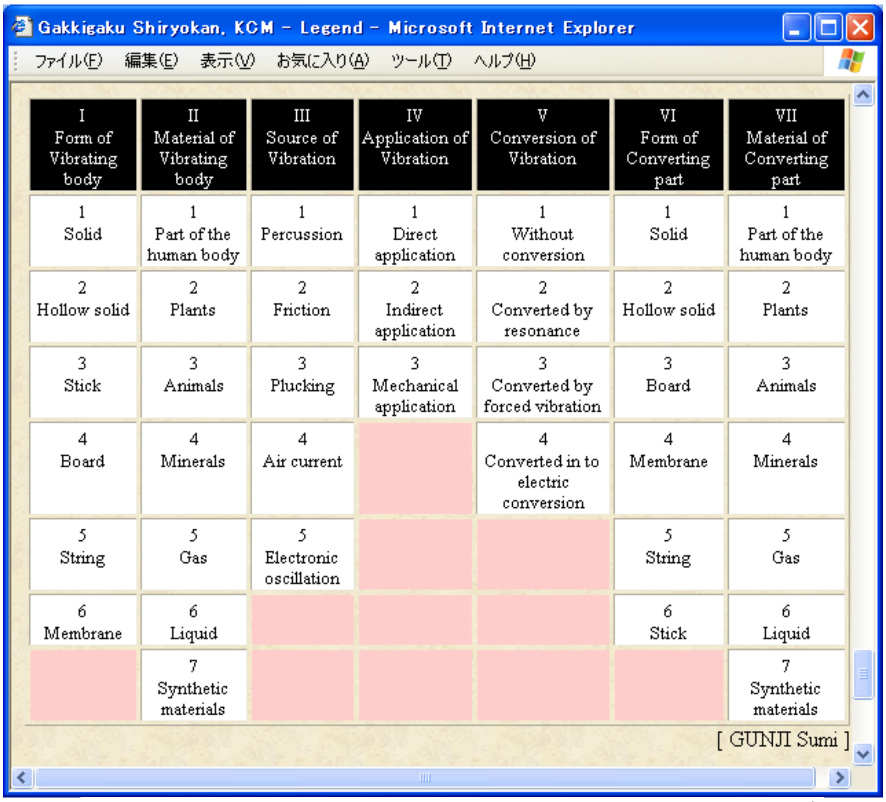
An analysis about sound preference tendency of children would be also helpful in development of the effective user interface on the multimedia databases, especially sound databases that museums have been developing or have developed.

As an application of sound preference tendency, I would like to propose the following user interface. Suppose that a music room like Horniman Museum in London where we can listen to the sound and read the explanations through the elaborate user interface, watching the real musical instruments.

In my dream user interface, the virtual character could ask children about their likes and dislikes concerning the musical instrument sounds. After a few questions concerning his/her preference, the system behind the user interface could analyze the main factors of his/her sound preference. In advance, the system should have analyzed a general preference tendency of children in the same region as his/her. The virtual character in the user interface would ask questions about their preferences to let children think deeply about the main factors and the reasons of their preferences interactively. The virtual character also would compare their preferences with the regional preference tendency and illustrate the comparison table or so.

If there were such a user interface, the children visitors would give their attention to watch the musical instruments and listen to the sounds. In addition, they may begin to think deeply why they like or dislike the musical instrument sounds.

In the paper, I propose the analysis of likes and dislikes about musical instrument sounds. In the next section, I describe musical instrument attributes that feature the sounds. In Section 3, a conjoint analysis will be explained as the sound preference analysis method. In Section 4, I will describe that the bird-eye tool I have developed is suitable as a user interface for the conjoint analysis.



I Form of Vibrating body	II Material of Vibrating body	III Source of Vibration	IV Application of Vibration	V Conversion of Vibration	VI Form of Converting part	VII Material of Converting part
1 Solid	1 Part of the human body	1 Percussion	1 Direct application	1 Without conversion	1 Solid	1 Part of the human body
2 Hollow solid	2 Plants	2 Friction	2 Indirect application	2 Converted by resonance	2 Hollow solid	2 Plants
3 Stick	3 Animals	3 Plucking	3 Mechanical application	3 Converted by forced vibration	3 Board	3 Animals
4 Board	4 Minerals	4 Air current		4 Converted in to electric conversion	4 Membrane	4 Minerals
5 String	5 Gas	5 Electronic oscillation			5 String	5 Gas
6 Membrane	6 Liquid				6 Stick	6 Liquid
	7 Synthetic materials					7 Synthetic materials

[GUNJI Sumi]

Figure 1: Prof. Gunji's Systematics of Musical Instruments.[4]

2. Gunji's Systematics of Musical Instruments

In this section, I shall explain attributes to feature musical instrument sounds.

I have decided to use Prof. Sumi Gunji's systematic methodology to express the musical instrument attributes[*]. There are too many classification methods about musical instruments around the world [1]. Therefore firstly I had difficulty in deciding which classification approach I should adopt. The classification method most widely used currently is the methodology by Hornbostel and Sachs named "Systematik der Musikinstrumente: Ein Versuch"[2,3].

The feature of Prof. Gunji's methodology is to consider musical instruments from the perspective of various phenomena of sound. Prof. Gunji explains the methodology as follows[4]:

As a result of this, it is clear that "a thorough division and systematization," i.e. classification by means of form and material can hardly be attained.

On the other hand it is not altogether impossible to observe and classify musical instruments from the perspective of various phenomena of sound, which is itself one of the physical phenomena of the cosmos. Among the classifications so far made, those which employed this type of methodology have obtained certain results; one such example can be seen in the classification system of Hornbostel and Sachs."

In Prof. Gunji's methodology that we call "systematics", seven important items have been selected from the factors which serve to generate the sound of the instrument (See Figure 1). I think that when we analyze a sound preference, we should use the factors which serve to generate the sound as the attribute of the instrument sound.

Another reason of this selection is that the method is suitable for ambiguous retrieval of musical instruments. In the paper, Nakamizo illustrates a query about Japanese Shamisen and Japanese Kokyuu which are similar instruments[5].

Because of these reasons, I have decided to adopt the Gunji's systematics factors as the attributes to feature the instrument sounds. To understand the systematics, the physics book about musical instruments is also helpful for me[6].

In the systematics, for example, the violin is

[*] Prof. Sumi Gunji is a former professor of Kunitachi College of Music in Japan and now retired.

expressed by [5322332] which means as follows:
(1) The form of the vibrating body is string [5];
(2) The material of the vibrating body is animals [3];
(3) The source of the vibration is friction [2];
(4) The application of the vibration is indirect [2];
(5) The conversion of the vibration is converted by forced vibration [3];
(6) The form of converting part is a board [3];
(7) The material of the converting part is plants [2].

If the fourth attributes "application of vibration" is a mechanical one [3], then almost all the instruments belong to the keyboard group. When we see the source vibration of these keyboard instruments, the keyboard instruments could be divided as follows:

1. Percussion: Piano/Clavichord[54***13***332]
   Carillon [24***13***1--],
   Glockenspiel [44***13***215]
2. Friction: Glass harmonica with a keyboard [24***23***1--][*]
3. Plucking Harpsichord/Spinet/Virginal [54***33***332]
4. Air current: Reed organ [44***43***215]
   Positive organ [45***43***265]

These systematic codes can show the difference between harpsichords and pianos on the third attribute "source of vibration" as harpsichords pluck strings with plectrums on the jacks and pianos strike strings with hammers. On the other hand, the systematic code of clavichords is the same as the piano code although the action mechanisms are quite different; the clavichord produces sounds by striking strings with small metal blades called tangents. The reed organ which belongs to the keyboard instruments is, however, a wind machine as shown in the systematic code.

On the attribute "application of vibration", some mechanization of simple musical instruments can be expressed as follows[7]:

(a) Panpipes [454***1***265] to Pipe organs [454***3***265],
(b) Chord Zithers [543***1***332] to Harpsichords [543***3***332], and
(c) Dulcimers [541***2***332] to Pianos [541***3***332].

Next let's see the systematics of reed instruments, woodwind and brass. Woodwind instruments with single reeds (e.g., Clarinets, Saxophones) and double reeds (e.g., Oboes, Bassoons) have the same code [4241265] as far as I know. On the other hand, although bagpipes have single beating reeds in the drones, the code is [424***2***265] as the players activate the reeds by squeezing a bag filled with air held under their arms[8].

The wind instruments with air reeds can be expressed by [***454*******]. Among them, the code of the instruments which include the air reeds is [454***2******] such as recorders [454***2***265] and ocarinas [454***2***215]. On the other hand, in the case of flutes [454***1***265] or Japanese shakuhachis [454***1***265], the players use their facial muscles and the shaping of the lips to make the air reeds; there is no air reed in the instrument.

In brass instruments such as trombones, cornets, trumpets, French horns, and tubas, the vibration body is the player's lips, which is expressed by [4***1***41265] where the [***1***] means a part of the human body. *Modern brass instruments use metal mouthpieces in the shape of a cup or funnel pressed against the player's lips (and none of them use reeds). The shape of these mouthpieces affects the sound; deep funnel-shapes, as on a horn, produce a smooth tone, while cup-shaped mouthpieces, as on a trumpet, result in greater sharpness*[8]. These differences can not be expressed on the systematic code.

3. Conjoint Analysis

In the section, firstly I shall explain a conjoint analysis method in general. Then I shall consider the case of the conjoint analysis on musical instrument sounds.

3.1. Conjoint Analysis

Firstly I would like to explain a purpose of conjoint analysis, citing a passage from the book of Aaker and Day[9]: *A major purpose of conjoint analysis is to help select features to offer on a new or revised product or service, to help set prices, to predict the resulting level of sales or usage, or to try a new-product concept. Conjoint analysis provides a quantitative measure of the relative importance of one attribute as opposed to another.*

[*] Although I have not see the instrument, I make the code of the glass harmonica with a keyboard "24231—" because the glass harmonica code is "24211—".

In conjoint analysis the respondent is asked to make trade-off judgments. Is one feature desired enough to sacrifice another? If one attribute had to be sacrificed, which one would it be? Thus, the respondent provides extremely sensitive and useful information. The usual problem is that preferences for various attributes may be in conflict or there may not be enough resources to all the preferences. The question usually is to find a compromise set of attribute levels.

The conjoint analysis is a procedure to find a concept with the maximum value of its total utility for consumers. The model of the total utility (or response) Ui for the i^{th} concept (conjoint card) from a subject is as follows:

$$U_i = \beta_0 + \sum_{j=1}^{p} u_{jk_{ji}}$$

where $u_{jk_{ji}}$ is the utility (part worth) associated with the k_{ji}^{th} level of the j^{th} attribute (factor) on the i^{th} concept and p is the number of attributes[10].

The input data are obtained by giving respondents descriptions of concepts, which represent the possible combinations of levels of attributes. We call them conjoint cards. Respondents then evaluate each concept in terms of overall liking, intentions to buy, or rank order of preference compared to other concepts[4]. Finally a respondent selects the rank order [1…n] of the cards. Instead of the rank order, the preference level of the conjoint card may be selected; for example a three levels, 1 to 3.

The conjoint procedure calculates the value of u_{jk} where $U_i \geqq U_k$ if the i^{th} rank order is smaller than k^{th} rank order. The SPSS conjoint analysis procedure uses ordinary least squares although other methods exist such as MONANOVA and LINMAP. Because the SPSS conjoint analysis is now widely used, I have also selected the SPSS package.

In the SPSS conjoint analysis results, a set of utility (part worth) values { u_{jk} } is shown. The u_{jk} is the utility (part worth) associated with the k^{th} level of the j^{th} attribute (factor) on the i^{th} concept.

Wittink and Cattin describe in the survey as follows[11]: *For the number of preference (tradeoff) judgments per respondent, we obtained a median value of* <u>*16*</u> *for the typical application. The reliability is also determined by the number of attributes used (a median of* <u>*eight attributes*</u>*) and the number of attribute levels (a median of* <u>*three levels*</u> *for the typical study).*

To make a set of conjoint cards which are combinations of the level values, we should use the method named <u>an orthogonal main-effects design</u>. It will find the smallest orthogonal plan to fit the attributes having at least as many combinations as requested[5]. Using the orthogonal main-effects design, we can drastically decrease the number of conjoint cards compared with one of the ordinary combination method. Then, it facilitates for a respondent to decide on the rank order and consequently the reliability of the results will become up.

3.2. The Case of Musical Instrument Sounds

Next let us consider a conjoint analysis method concerning the sound preference. There are some problems to overcome so that we can apply the conjoint analysis on the musical instrument sounds. The problems are as follows:

(1) It is difficult to determine a representative instrument and masterpiece played for one concept.

(2) In the Gunji's systematics:

- ① **The number of attributes and the levels is too large to manage while we conduct a conjoint analysis on the systematics.**
- ② **Some attributes partly depends on the others.**
- ③ **Sometimes there is no existing musical instrument corresponding to a concept to be generated by the orthogonal main-effects design.**

I shall explain these problems. The first problem is that the relationship between a conjoint card and the existing instrument is one to many. Strictly speaking, the relationship is many to many because one instrument may have several playing methods such as plucking and friction.

For example, the oboe and the clarinet belong to the same concept [4241265] because the two instruments belong to woodwind instruments.

Then the difference between single reeds (the clarinet) and double reeds (the oboe) can not be expressed there. Therefore we have difficulties while selecting the representative instrument corresponding to one systematic code.

There is also a problem of masterpieces to be played with the instruments. I focus on just the sound preference. Therefore I think that we should use the same masterpiece for all the musical instruments. At least, the same masterpiece should be used as widely as possible in order to compared one instrument sound to others. It may be, however, difficult to find many recordings of the same masterpiece with various musical instruments.

Next let us consider the schema of Gunji's systematics. In the systematics, the number of the attributes is seven. The number of levels is from three to seven (See Figure 1). These numbers are too large for the conjoint analysis. Malhotra describes that the number of attributes should be five or so[12]. Therefore we have to select a subset among the systematics. It will, however, be so prudent to select the musical instrument attributes and the levels.

In addition, we should keep in mind the following restriction in the conjoint analysis: any two attributes must be independent of each other. Thus, we should follow the restriction to conduct right conjoint analysis. However, in the systematics some attributes partly depends on the others. The concrete examples are as follows:

- If the instrument is an electronic one, there exist no sixth and seventh attributes like electronic organs [42534--].
- If the instrument has no conversion part, there exist no sixth and seventh attributes as follows: Bell [24121--], Slit drum/Rattle [22121--], Frame drum [63111--], and Cymbals [44121--].
- If the instrument is a string one, the conversion part form is almost a board [5*****32] such as violins and lutes or a hollow solid [5*****15] such as musical sticks/raft zithers with hollow gourds. One of the exception string instruments is sanshins [5332343].
- There is no instrument with string conversion parts [*****5*]. The exceptions are some musical bows such as Bushman's nxonxoros[13].
- If the instrument is a wind one, the conversion part is made of air and its form is a stick or a solid. Namely the patterns [4*4*265] [4*4*215] are frequently appeared.

Therefore, when we apply the conjoint analysis on the systematics, we will have to transform the schema of the systematics. More discussion about the systematics concerning the sound preference analysis should be conducted after some trials on the conjoint analysis.

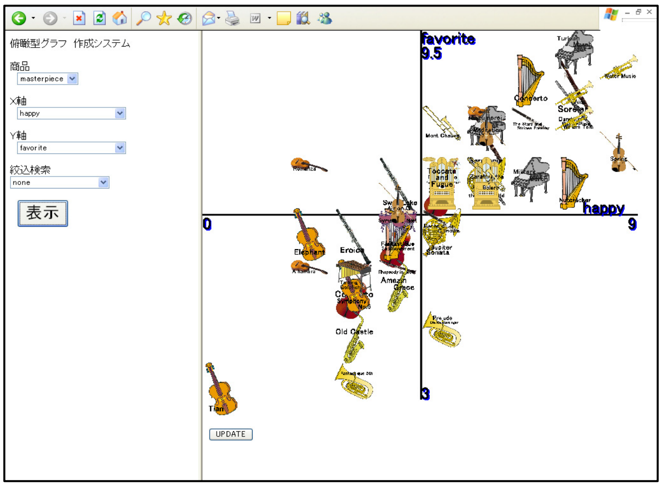


Figure 2: The bird-eye tool for a conjoint analysis.

4. Bird-eye Tool

As a user interface for respondents in a conjoint analysis, I propose the bird-eye tool which I have developed. When two attributes of which types are integer or floating point are selected among many attributes, the two attribute values are used as x and y coordinates on the layout sheet.

The bird-eye tool is a Web-based one. On the coordinate point, the corresponding item icon image is located as shown in Figure 2. The respondent can move the icon of which location becomes its rank order or the scaling rank value such as one to seven.

The respondent can handle the image icon as the conjoint card made of paper. Double click of the icon makes the detail information of the conjoint card displayed in a separate window. There a sound button is laid out by which the respondent can listen to the instrument sounds. The sounds are supposed to be in advance stored in a multimedia database.

The advantages of the bird-eye tool while conjoint analysis are considered as follows:

(1) The original paper-based conjoint card cannot include the music data. On the other hand, the bird-eye tool can facilitate the music listening.

(2) The bird-eye tool would facilitate matters for the respondent because two indices are laid out on the same sheet; In Figure 2, the index “favourite level” and the index “happiness level” are selected. The latter means how much the sound can make the respondent happy. When a respondent tries to decide the rank order, I think that a comparison on such a two-dimensional sheet would facilitate the concept comparison, compared with the one-dimensional comparison.

5. Conclusion

In the paper, I proposed analysis of likes and dislikes about the musical instrument sounds. As the classification methods about musical instruments to identify the sound, I will adopt the Gunji’s systematics because the methods are based on the generation process of the sounds. In addition, I have discussed the problems when I try to apply the conjoint analysis on the sound preference concerning musical instruments. In addition, as a user interface for a respondent in a conjoint analysis, the bird-eye tool which I have developed would be more helpful than the existing paper-based conjoint cards.

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