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Multidimensional Analysis of Onomatopoeia
—A note to make sensory scale from words—

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ABSTRACT

Onomatopoeic words from the clusters of talking, laughing, and crying were analyzed using multidimensional analysis. It was found that each of the word within the cluster could be located along the some dimension representing the psychological magnitude. Furthermore, a direct magnitude estimation scaling method was found to be valid to make sensory magnitude scale from onomatopoeic word stimuli.

1. INTRODUCTION

Onomatopoeia indicates word formation based on the imitation of natural sound, for example *whisper, bang* or *hiss* in American English and *pera-pera, siku-siku,* or *gera-gera* in modern Japanese. The word is based on either the nature of the sound itself, as *crash* or the name of the source of the sound, as *cuckoo.* The interpretation of sound changes as language changes. In particular, a large amount of onomatopoeia words are found in modern Japanese as function word like an adverb. In philosophical discussion in ancient Greece, onomatopoeic words were cited as an argument for the "naturalness" of language or the appropriateness of words to their meaning. A hypothesis which language originated in the imitation of natural sounds is called the bowwow theory.

The purpose of the present investigation is twofold: Firstly, to find a cluster of onomatopoeia words in which their meaning originated in the same emotion-based psychological state. The frequency-table based on an association response to stimulus word was made for this purpose. Secondly, to analyze their cluster structures by applying a multidimensional analysis and then try to make sensory scale along dimension.

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2. CLUSTERS FOR ONOMATOPOEIA

469 onomatopoeia words (mimesis-oriented words were also included) having a form of double-repeated syllable (xyxy-type), e.g., *kera-kera* (cackle), were collected from dictionaries (Amanuma, 1973; Asano, 1978; Fujita & Akiyasu, 1984; Ono, 1984; Shiraishi, 1982; Mito & Kakehi, 1984). The selection criterion was the observed frequency of appearance across the dictionaries, i.e. at least two dictionaries had to be adopted the given word. 290 college student, aged from 18 to 25, described a response word for each of the 469 word using free association procedure. Then the responded words (a total of 136010 words) were categorized and counted in terms of a part of speech using dBASE-III program.

Further, the inverted file based on response word data was created by using 469 by 136010 (stimulus vs response word) matrix. Thus the onomatopoeia database summarized into 1451 responded words. Three of the specific clusters, *talking laughing* and *crying,* were extracted as shown in Table 1. Frequency of responding word category for each stimulus (onomatopoeia) word was shown in Table 2–4. Note that percentage shown in parenthesis indicates the contribution factor for each of the onomatopoeia, e.g. *hiso-hiso* in Table 2 has 84% contribution from category *talking*.

Table 1 Three major clusters for onomatopoeia words.

talking		laughing		crying	
pera-pera	19%*	kusu-kusu	17%	siku-siku	21%
wai-wai	15	gera-grea	15	boro-boro	16
zuke-zuke	14	kera-kera	15	oi-oi	15
bera-brea	13	keta-keta	14	horo-horo	13
boso-boso	13	hera-hera	12	waa-waa	5
sura-sura	8	niya-niya	8	hii-hii	5
haki-haki	5	nitainita	7	hiku-hiku	5
moso-moso	2	niko-niko	6	pii-pii	4
koso-koso	2	kutu-kutu	3	ome-ome	4
rou-rou	2	kara-kara	2	mero-mero	3
butu-butu	2	nicha-nicha	1	poro-poro	3
potu-potu	1			gyaa-gyaa	3
hiso-hiso	1			kuyo-kuyo	2
botu-botu	1			gusha-gusha	1
pecha-pecha	1				
munya-munya	1				

*Percentage as ordered in frequency

3. PAIR-WISE DISSIMILARITY RATING

Following three clusters were chosen for further analysis:

(1) Cluster related with *talking*: *pera-pera*(glibly), *wai-wai* (noisily), *zuke-zuke*(blunt-

Table 2 Freqeuncy of responding word category for onomatopoeic stimulus word hanasu (talking)*

hiso-hiso**	(84%)***	bera-bera	(82%)	boso-boso	(75%)
+rumor	50%	+chat	78%	+talk	59%
+talk	26	+talk fast	4	+rumor	10
+backbiting	8	annoying	2	+murmur	6
others	16	others	16	others	25
pecha-pecha	(71%)	pera-pera	(69%)	haki-haki	(68%)
+chat	71%	+chat	54%	+answering	28%
get wet	7	+English	15	+say	20
lick	3	thin	8	+responding	12
others	19	paper	6	+speech	8
		others	17	others	32
munya-munya	(63%)	wai-wai	(56%)	zuke-zuke	(56%)
+talk in sleep	63%	+make merry	56%	+say	56%
sleep	9	company	6	freely	5
eat	6	party	4	audaciously	4
others	22	happy	4	others	35
		others	30		
sura-sura	(51%)	butu-butu	(50%)	koso-koso	(27%)
+say	27%	+disagreeableness	43%	robbery	23%
+read	17	pimple	23	hide	21
write	16	+soliloquy	7	+talk	15
+English	7	discontent	6	+secert	12
others	33	others	21	others	29
rou-rou	(25%)	moso-moso	(10%)		
candle	15%	move	16%		
+chat	8	+speak	10		
+sing	6	eat	4		
+reading	6	others	70		
+speech	5				
others	60				
potsu-potsu	(7%)				
rain	48%				
pimple	11				
+talk	7				
drop	5				
others	29				

*Total number of subject is 290 college students
**Stimulus onomatopoeic word
***Summed percentage related with the response category talking.
+Percentage of the response word related with the response category talking

Table 3 Frequency of responding word category for onomatopoeic stimulus word warau (laughing)*

kusu-susu**	(94%)***	keta-keta	(85%)	nicha-nicha	(25%)
+laugh	94%	+laugh	85%	+laugh	25%
others	6	others	15	lewd	14
				gum	5
				others	55
niko-niko	(71%)	gera-gera	(80%)	kera-kera	(82%)
+smile	40%	+laugh	80%	+laugh	82%
+laugh	31	vulgar	3	girl	2
others	29	others	17	others	16
kutu-kutu	(16%)	hera-hera	(73%)	niya-niya	(48%)
cook	47%	+laugh	73%	+laugh	48%
+laugh	16	light	3	lewd	18
shoes	11	stupid	3	scheme	3
others	26	others	21	others	31
kara-kara	(11%)	nita-nita	(45%)		
throat	16%	+laugh	45%		
+laugh	11	lewd	17		
thirsty	6	others	38		
can	6				
others	61				

*Total number of subject is 290 college students
**Stimulus onomatopoeic word
***Summed percentage related with the response category laughing.
+Percentage of the response word related with the response category talking

ly), *bera-bera*(prattle), *boso-boso*(talking in a subdued), *sura-sura*(fluently), *haki-haki* (answer promptly), *moso-moso*(mumbling), *koso-koso*(whisper), *rou-rou*(resonant), *butu-butu*(grumble), *potu-potu*(trickling), *hiso-hiso*(secretly), *botu-botu*(little by little), *pecha-pecha*(gabble), *munya-munya*(mumble).

(2) Cluster related with *laughing*: *kusu-kusu*(titter), *gera-gera*(laugh loudly), *kera-kera* (giggle), *keta-keta*(cackle), *hera-hera*(gabble), *niya-niya*(grin), *nita-nita*(simper), *niko-niko* (smilingly), *kutu-kutu*(snicker), *kara-kara* (laugh discordantly), *nicha-nicha*(sticky laugh).

(3) Cluster related with *crying*: *siku-siku*(sob), *boro-boro*(shed large tear-drops), *oi-oi*(bawl), *horo-horo*(tears fell in drop), *waa-waa*(howl), *hii-hii*(screaming), *hiku-hiku* (twitch), *pii-pii*(peep), *ome-ome*(tamely), *mero-mero, poro-poro*(tears trickled down), *gyaa-gyaa*(scream), *kuyo-kuyo*(worry), *gusha-gusha*(drenched).

Pair-wise dissimilarity rating (7-point-scale) for each cluster was done by each of 99 college students: Number of combination pairs $((n(n-1))/2)$ for *talking, laughing*, and *crying* was 120, 55, and 91, respectively.

Table 4 Frequency of responding word category for onomatopoeic stimulus word naku (crying)*

siku-siku**	(83%)***	horo-horo	(46%)	oi-oi	(52%)
+cry	70%	+cry	46%	+cry	52%
+tear	13	bird	22	shout	21
sorrow	3	+tear	10	others	27
pain	3	others	22		
others	11				
poro-poro	(63%)	hii-hii	(20%)	pii-pii	(16%)
+tear	53%	+cry	20%	bird	53%
drop	16	scream	13	+cry	16
+cry	10	painful	9	whistle	7
others	21	breath	3	others	24
		others	55		
gusha-gusha	(4%)	kuyo-kuyo	(7%)	waa-waa	(28%)
paper	26%	worry	55%	make merry	35%
crash	17	+cry	7	+cry	20
hair	11	puzzled	4	shout	8
+cry	4	others	34	joy	7
others	42			others	30
boro-boro	(21%)	ome-ome	(14%)	gyaa-gyaa	(36%)
+tear	21%	withdraw	23%	+cry	36%
old	14	+cry	14	noisy	25
split	8	get back	4	baby	24
clothes	6	others	59	others	15
others	51				
moro-mero	(12%)	hiku-hiku	(18%)		
+cry	12%	+cry	18%		
drama	10	hiccup	15		
love	7	cramp	12		
others	71	others	55		

*Total number of subject is 290 college students
**Stimulus onomatopoeic word
***Summed percentage related with the response category crying
+Percentage of the response word related with the response category crying

4. Multidimensional Analysis

A multidimensional analysis (ALSCAL: Alternating Least Squares Scaling method; Young & Lewyckyj, 1979) was performed to dissimilarity data matrices. Non-metric data was used and Euclidian distance model (2D) was applied. The algorithm of ALSCAL has an iterative computation, where each iteration has two steps, an optimal scaling and a model estimation step. In the former step the data are scaled so that they are a least squares fit to the distances computed from the model and in the latter step the parameters of the model are estimated so that the distances computed from them are a least squares fit to the optimally scaled data. The two steps are alternated until convergence is attained. (Takane, Young & de Leeuw, 1977).

5. Magnitude Estimation

Using psychophysical magnitude estimation procedure (Osaka, 1987), 19 college students were asked to estimate the magnitude of each of the selected onomatopoeic word in terms of its dimension 1 obtained in the MDS analysis. The range of the scale was from 1 to 100 and the subject was asked to rate the most high magnitude word as "90". This value was used as the reference value by subject. They were asked to assign the value in terms of intensity magnitude.

6. Results and Discussion

The calculated 2D Euclidian plots were shown in Figures 1–3 for cluster of *talking, laughing,* and *crying,* respectively.

For the cluster of *talking* calculated s-stress according to Young's formula was 0.10 and stress by Kruskal's formula was 0.13. The squared correlation (rsq) which can be interpreted as indicating the proportion of variance of the disparities which is accounted for by the ALSCAL model was found to be 0.93 here. These values suggest that 16 onomatopoeic words could be appropriately located within 2D space. Dimension 1 clearly indicates overall voice magnitude (clearness) of *talking*; as the value increases along dimension 1 the magnitude increases (e.g., *haki-haki, sura-sura, pera-pera, bera-bera* from right to left) whereas the magnitude decreases as the value decreases (e.g., *hiso-hiso, moso-moso, munya-munya, boso-boso, koso-koso, botu-botu* from right to left). Thus a sensory scale could be made along dimension 1. Interpretation along dimension 2 appears difficult, however two sub-groups for *talk to oneself*

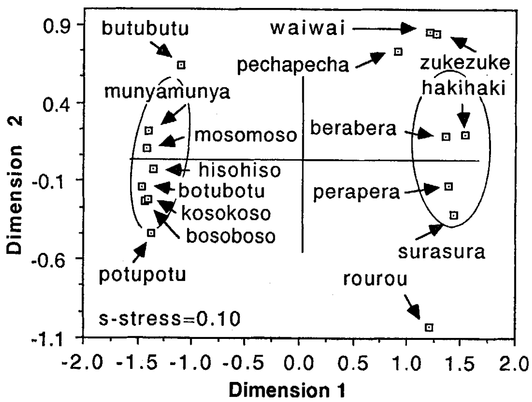

Fig. 1. Plot of dimension 1 vs dimension 2 for the onomatopoeic stimulus word in the cluster *talking*.

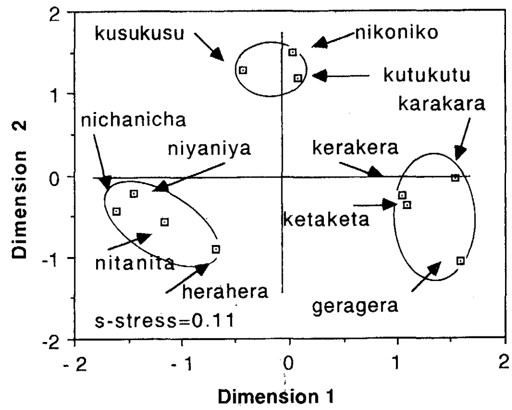

Fig. 2. Plot d of dimension 1 vs dimension 2 for the onomatopoeic sitmulus words in the cluster *laughing*.

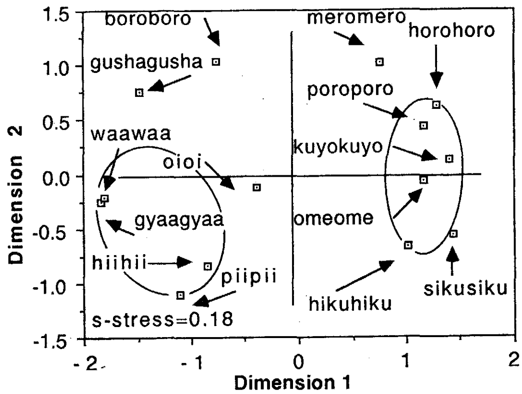

Fig. 3. Plot of dimension 1 vs diemsnion 2 for the onomatopoeic stimulus words in the cluster *crying*.

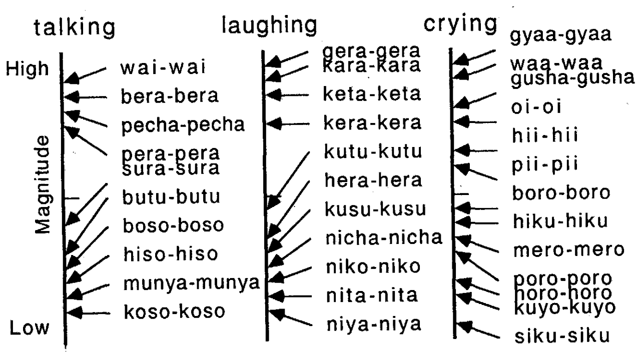

Fig. 4. Sensory scales using magnitude estimation method along dimension 1 obtained by MDS.

(e.g., *munya-munya, moso-moso, butu-butu*) and for *private talk* (e.g., *hiso-hiso, koso-koso, boso-boso*) could be found at the left-side part of the configuration.

For the cluster of *laughing* s-stress, Kruskal's stress, and rsq was 0.11, 0.11, and

0.92, respectively. These values again indicate that 11 onomatopoeic words could be appropriately located within 2D space. Dimension 1 clearly indicates the magnitude of *laughing*; as the value increases along dimension 1 the magnitude increases (e.g., *gera-gera, kara-kara, keta-keta, kera-kera* from right to left) whereas the magnitude decreases as the value decreases (e.g., *hera-hera, nita-nita, niya-niya, nicha-nicha* from right to left). Again a sensory scale could be made along the magnitude dimension. Interestingly enough, the right and left sub-group reveals auditory(voice)-oriented and visual(facial)-oriented expression, respectively. Thus *laughing* appears to include double components in their perceptual representation. Interpretation along dimension 2 appears difficult, however one sub-group suggests some kind of emotion-free double component (e.g., *niko-niko, kusu-kusu, kutu-kutu*).

For the last cluster, *crying*, s-stress, Kruskal's stress, and rsq was 0.18, 0.16, and 0.85, respectively. These values indicate that 14 onomatopoeic words could be appropriately located within 2D space although the fitness appears somehow low as compared with *talking* and *laughing*. Dimension 1 clearly indicates the magnitude of *crying*; as the value decreases along dimension 1 the magnitude increases (e.g., *hii-hii, pii-pii, waa-waa, gyaa-gyaa* from right to left) whereas the value increases the magnitude decreases (e.g., *hiku-hiku, poro-poro, horo-horo, kuyo-kuyo, siku-siku* from left to right). Thus a sensory scale could be made along the magnitude dimension. However, it should be noted that several words have double components (auditory and visual) in their perceptual representation (e.g., *boro-boro, gusha-gusha, horo-horo, poro-poro*) as observed in *laughing*.

As shown above, although the onomatopoeic words appear to evoke some multimodal representation from major sensory attributes such as hearing and vision, it appears possible to make *direct* sensory scale along some dimension using onomatopoeic words.

Figure 4 shows the results from magnitude estimation for *talking, laughing,* and *crying*. The analysis of variances indicate the significant main effects for *talking* ($F(9,153)=102.19$, $p<.01$), *laughing* ($F(10,180)=50.60$, $p<.01$), and *crying* ($F(12,216)=40.35$, $p<.01$). An overall location and order of the stimulus word along the sensory magnitude appear to have a similar tendency as that of obtained in MDS. This suggests the validity of magnitude estimation scaling to make sensory magnitude scale in terms of intensity dimension.

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