The Applicability of Sounds to Interface Design of the Digital Camera

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Abstract:

This study uses digital camera as an example to discuss the user's cognitive image towards sound signal to generalize the sound signal's required conditions, and to the correlation between sound image and operational function, which can conform with the digital camera's user interface.

This study mainly uses the Likert Attitude Scale and Semantic Differential Method to carry out the two-stage experiment investigation, and use the SPSS statistical software to proceed the statistical analysis of the result. The result can be mainly divided into three parts: 1. the average of the sound sample's applicability evaluation. 2. the analysis of the function's correlation. 3. SD evaluation factor analysis, and cluster analysis.

The experiment result show that the digital camera's sound signals, "turning on-turning off", "focus correction-confirmation", and "low battery-focus error", all has the commonness in cognition for the user. And the user's image cognition about the digital camera's sound signals is extracted four components by the factor analysis. It can be mainly divided into the emotion component, the melody component, the rhythm component, and the discrimination component, and then divide the 18 sound samples into 5 groups by the cluster analysis to conclude the sound and image characters and the sound signal applicability design a operational function should equip.

Key words: *applicability, sound, interface, digital camera*

1. Introduction

1.1 Background of The Study

Nowadays, most information technology products use the digitals to present pictures, animations or lighting and colors. These kinds of visual operational interfaces to accompany with the assistant sound signal can achieve the purpose of, informing or warning effect in human-computer interaction. For example, the layered windows of the computer interface, cellular phone, PDA, etc. If the conveyance of the sound signal can not fit in with the cognition of the user, it may lead to the confusion in discrimination, and then cause the misunderstanding. Hence, the relevant design, research and development of human machine interface have become an indispensable part for an industrial designer.

1.2 Purpose of The Study

According to the concept of sound interface and human-computer interaction, the product can use the interface to convert the message into visual or audio form and convey it to the user. The user, then, can proceed the

operational feedback (see fig.1) through the process of message discrimination, decoding and cognizing.

This study uses digital camera as an example to discuss the user's cognitive image towards sound signal to generalize the sound signal's required conditions, and to the correlation between sound image and operational function, which can conform with the digital camera's user interface.

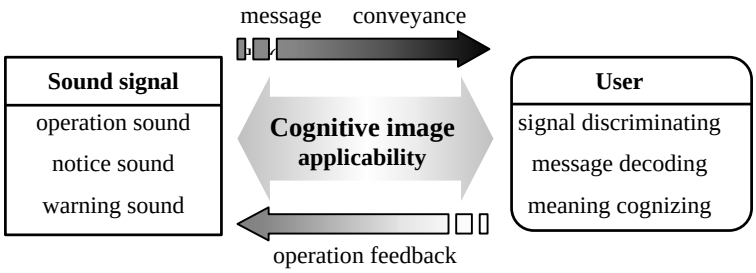

Fig.1 The conceptual figure of the sound operational interface and human-computer interaction.

2. Literature Review

In the literature review, first is to discuss the effect of the sound signal in operational interface. Second is to understand the factors, which affect the user's reflection towards the operational interface.

2.1 The Effect of Sound Signal

The Japanese scholar, Toshiki YAMAOKA, discover in the investigation of "the user interface's designing principles"[1] that one of the most obvious problems when a user operates is "getting anxious without feedback response from the computer". And the sound signal can just provide the applicable cue effect. Let the user proceeds the operation more efficiently. If visual effect is the basic feedback, then the sound effect is the strengthening of message [2]. This shows that if the information technology products use the sound signal's conveyance well, it can ease the burden of taking visual as the main focus, and enhance the learning efficiency of high interface.

2.2 The Factors, Affect The Sound Signal's Applicability

A good design of operational interface conveyance can improve the accuracy and smooth of the operation efficiently. Factors, which influence operational interface conveyance, can be divided in three parts as follow:

1) Cognitive type: According to the cognitive stimulus of the product, most electronic products' operational interfaces focus mainly on the visual and audio effect; however, different cognitive type has diverse period of responding. Generally speaking, the audio stimulus is faster than the visual one's simple response [3].

2) Anticipation: Abemethy (1987) indicated that in human-computer interaction, the user will speculate when will the signal appear, and project the applicable response into the short-term memory in advance, but shorten the responding time in the real action [4]. It means to provide the prior clue to the situation, and make use of the optional notice and check the target's stimulus, then make the applicable response [5].

3) Compatibility: The "Compatibility" is the occurrence of the "stimulate – respond" or the correlation between the system behavior and the worker's expectation. If the compatibility exists between stimulating and responding, the responding time will be shortened; whereas, the incompatibility will lengthen the responding time [6].

3. Methodology and Experiment

3.1 Methodology

This study mainly uses the Likert Attitude Scale and Semantic Differential Method to carry out the two-stage experiment investigation, and use the SPSS statistical software to proceed the statistical analysis of the result. The result can be mainly divided into three parts: 1. the average of the sound sample's applicability evaluation. 2. the analysis of the function's correlation. 3. SD evaluation factor analysis, and cluster analysis.

3.2 Experiment Definition

1) The selecting of the function item: to invite twenty subjects to select the digital camera's function, which they think requiring the assistance of the sound signal most. The result shows that the first eight places are turning on, turning off, focus correction, focus error, confirmation, cancel, shutter and low battery.

2) The sample gathering of sound signal: At the beginning, this study gathered 68 sound samples, then invited ten subjects to use the 8 functions, selected the more applicable sound signal separately, and concluded 30 sound signals finally. This study is divided into four parts, A. 8 single sound types, B. 11 dual sound types, C. 5 simulating sound types, D. 6 melody sound types, according to the sound types. Please refer to tab.1 to see each sound sample's information.

3.3 Experiment Proceeding

1) Applicability evaluation's experiment: There are 8 functions. The subjects should listen and determine the applicability of the thirty sound samples according to each operational item. From "not quite applicable" to "quite applicable", it divides into five stages, and the subjects should grade them from 1 to 5. The valid samples are fifty people. The evaluation results of this experiment are collected and organized in tab.1.

2) SD evaluation's experiment: To select 3 most applicable samples, the 18 sound signals in the tab.1, which the sample numbers' field are fill-patterned, from each operational function in the last stage's results, and aim at the 16 opposite adjectives to do the cognition evaluation. The valid samples are 50 people.

Tab. 1 The information and operational function's applicability of the sound signal sample.

category	number	tone description	pronunciation trait	time (sec.)	operational function applicability evaluation's average statistics								sample sources
					Turning on	Turning off	Focus correction	Focus error	Confirmation	Cancel	Shutter	Low battery	
A. Single sound	A1**	du	short single sound	0.144	2.64	2.56	3.66	2.86	3.60*	3.22	2.58	2.76	Select (Kyocera)
	A2	di	short single sound	0.145	2.42	2.54	3.50	2.68	3.54	3.12	2.52	2.82	Select (Olympus)
	A3	du	short single sound	0.078	2.06	2.42	3.04	2.76	3.12	3.20	2.48	2.52	Select (Sony)
	A4	bi	short single sound	0.162	2.36	2.34	2.80	2.96	3.12	2.62	2.44	2.66	Shutter(Fuji)
	A5	bi~	long single sound	1.117	2.66	3.44	2.50	3.24	2.56	2.96	2.42	4.06	No memory card (Olympus)
	A6	du---	interval single sound	0.496	2.46	2.76	2.72	4.04	2.22	2.70	2.26	4.26	No memory card (Sony)
	A7	du	short single sound	0.242	2.14	2.70	2.96	2.96	3.18	3.12	2.06	3.16	Low battery (Panasonic)
	A8	den	short single sound	0.234	2.04	2.74	2.10	3.90	2.42	3.34	1.84	2.62	Low battery warning(Windows)
B. Dual sound	B1	du-den	gliding dual sound	0.556	2.62	2.86	1.90	3.74	1.94	2.92	1.84	2.86	Power on (Minolta)
	B2	din-dun	gliding dual sound	0.388	2.56	3.32	2.28	3.56	2.62	3.32	2.34	2.82	Power off (Windows)
	B3	di-di	flat dual sound	0.122	2.84	2.84	3.88	2.82	3.50	2.98	2.66	3.22	Focus correction (Canon)
	B4	du-i	lifting dual sound	0.321	2.48	2.84	2.64	2.68	3.48	3.22	2.32	2.50	Focus correction (Minolta)
	B5	dan-dan	flat dual sound	0.200	2.42	2.66	4.22	2.88	3.26	3.32	2.76	3.52	Focus correction (Sony)
	B6	don-don	flat dual sound	0.418	1.96	2.00	1.78	3.52	1.80	2.82	1.74	2.66	Focus error (Fuji)
	B7	du-wu	gliding dual sound	0.256	2.70	3.10	2.68	3.46	2.68	3.22	2.30	2.74	Select (Minolta)
	B8	du-di	lifting dual sound	0.167	2.98	2.90	3.76	2.30	3.92	2.98	2.62	2.34	Confirmation (Sony)
	B9	du-du	lifting dual sound	0.095	2.32	2.40	3.28	2.64	3.06	3.02	2.70	2.20	Confirmation (Sony)
	B10	di-di	flat dual sound	0.354	2.82	3.02	4.06	3.18	3.06	3.32	2.86	3.94	Shutter (Olympus)
	B11	dun-di	lifting dual sound	0.326	2.78	2.94	2.90	3.00	3.74	3.26	2.76	2.50	Deleting warning (Minolta)
C. Simulating sound	C1	simulating	shutter snap sound	0.203	1.44	1.50	1.70	1.44	1.72	1.54	4.66	1.28	Shutter (Canon)
	C2	simulating	spring sound	0.251	1.58	1.76	1.68	2.68	1.74	2.26	2.52	1.74	Shutter (Canon)
	C3	simulating	shutter snap sound	0.432	1.64	1.58	1.48	1.34	1.66	1.30	4.58	1.26	Shutter (Minolta)
	C4	simulating	shutter snap sound	0.367	1.50	1.38	1.40	1.24	1.64	1.34	4.68	1.16	Shutter (Sony)
	C5	simulating	spring sound	0.699	2.22	2.82	1.50	3.28	1.74	2.34	1.70	2.72	Low battery warning (Canon)
D. Melody sound	D1	lifting	synchronized string melody	1.050	2.54	2.36	1.54	2.08	1.78	1.90	1.66	2.02	Power on (Canon)
	D2	spring	single sound melody	0.869	3.66	3.48	2.46	2.40	2.84	2.72	2.42	2.46	Power on (Fuji)
	D3	lifting	synchronized string melody	1.402	3.74	3.44	1.48	1.52	2.34	1.84	2.04	1.60	Power on (Minolta)
	D4	gliding	single sound melody	0.275	1.60	2.74	2.22	3.46	2.48	3.74	2.00	2.44	Power off (Sony)
	D5	lifting	single sound melody	0.339	3.52	3.10	3.08	2.20	3.52	2.98	2.86	2.22	Open the setting menu (Sony)
	D6	gliding	single sound melody	0.306	3.08	3.72	2.94	2.52	3.36	3.34	2.62	2.66	Close the setting menu (Sony)

* The average fill-patterned shows that this function is the applicability sample in the first three places.

** The number fill-patterned, shows that it has the applicable operation function, and will be the SD evaluation's experimental sample.

4. The applicability of result

After analyzing the 50 subjects' responses, 18 subjects, which get higher scores in the applicability evaluation, A. 4 single sound types, B. 6 dual sound types, C. 3 stimulating sound types, D. 5 melody sound types, are selected from the 8 items. Please refer tab.1 to see the evaluation result.

The following is to analyze the 18 sound signals' evaluation scores in the operational function. Fist is to discuss the applicability of the sound signal's type and the functional corresponding. Second is to examine the evaluation value's correlation between the 8 functions.

4.1 The sound signal's type and the operational function's applicability analysis

A. The single sound type's sound signal: In fig.2, it can be mainly divided into two groups, A1 is one group, A5, A6 and A8 are the other. From the diversity, A1 scores pretty high in "focus correct" and "confirmation", and A5, A6 and A8 are tending to score high in "turning off", "focus error" and "low battery". From the common point, these two groups both show the low applicability in "turning on" and "shutter", and unapparent results in "cancel", which the evaluation value mass in the middle.

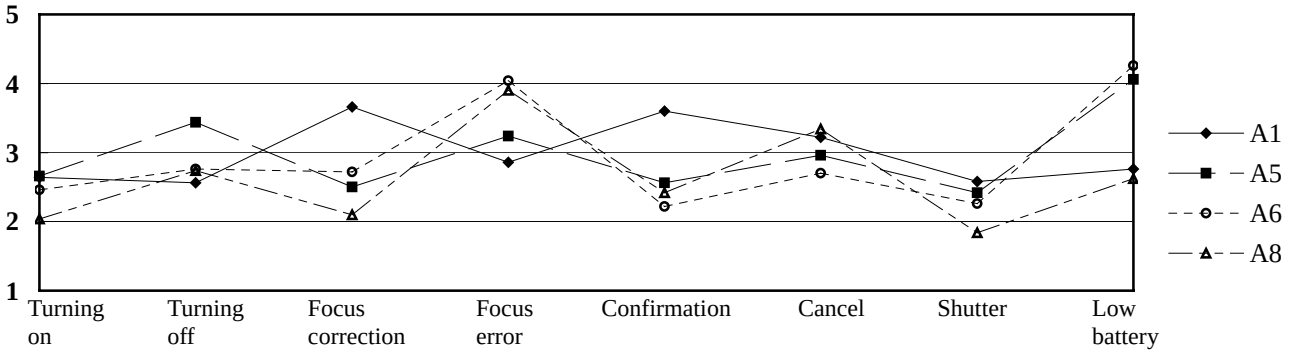

Fig. 2 The applicability evaluation of the single sound type.

B. The dual sound type's signal: In fig.3, the dual sound score high in "focus correction", "focus error", "confirmation" and "low battery", and low in "turning on" and "shutter". In the sample, B1 is the gliding dual sound, and shows opposite evaluation with other samples in "focus correction", "focus error" and "confirmation".

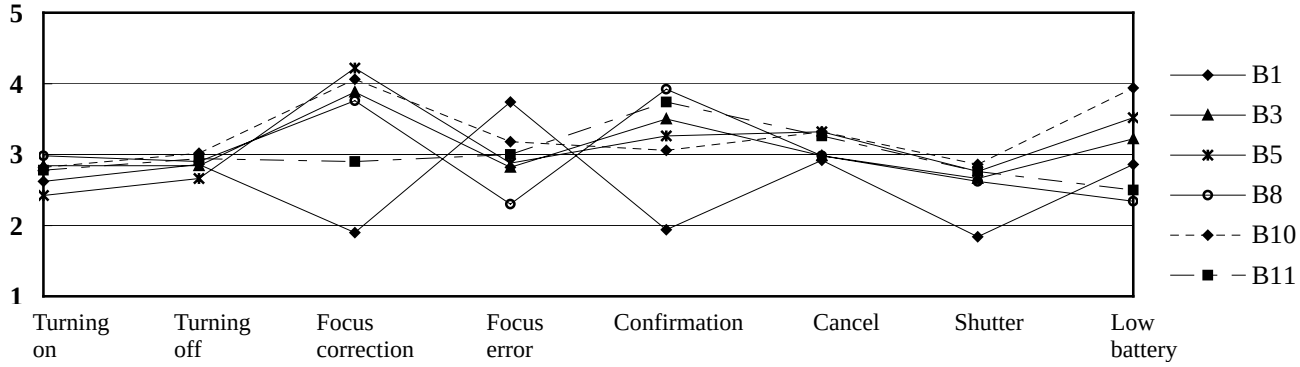

Fig. 3. The applicability evaluation of the simulating sound type.

C. The simulating sound type's signal: In fig.4's entire evaluation results, it can be seen that the simulating sound's sound signal belong to an unusual type. It is obvious that the simulated shutter sound signal has extremely high applicability in "shutter", but this kind of situation is probably affected by the direct image correlation between sound signal and function. It also proves that the cue way of the image analogy's sound signal can enhance the applicability efficiently.

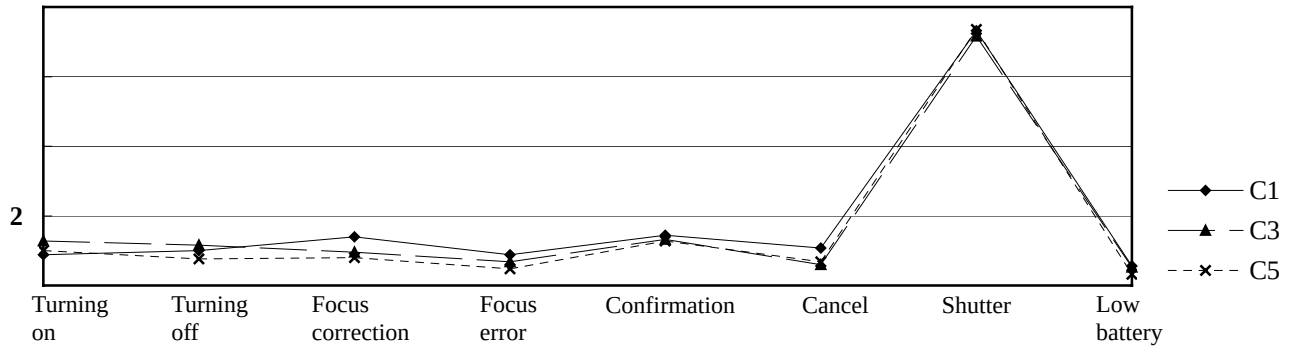

Fig. 4 The applicability evaluation of the dual sound type.

D. The melody sound type signal: In fig.5, the melody sound type's evaluation value has no particular applicable in the 8 operational functions, but there are many functions' evaluation value below 2, which belong to extremely inapplicable. To compare from the melody character, the "turning on", "focus correct", and "confirmation" functions, are applicable to adopt the lifting melody sound. Oppositely, the "turning off", "focus error", and "cancel" functions are applicable to the gliding melody sound.

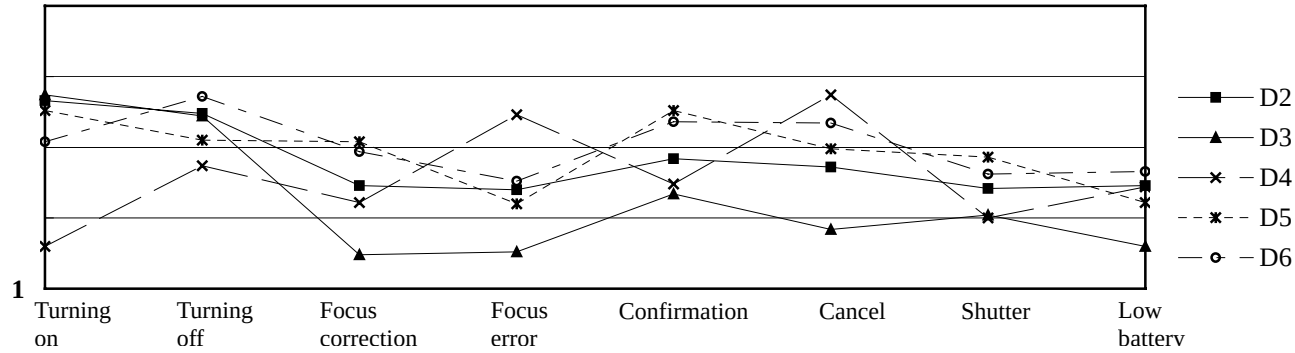

Fig. 5 The applicability evaluation of the melody sound type.

4.2 Operational functions' correlation analysis

This study makes use of the correlation analysis to examine the sound sample's applicability evaluation value. The result shows in tab.2. In the sound and signal's correlation examination between functions, the applicability of "turning on" and "turning off" has high correlation. The sound signal of "confirmation" and "focus correction" has the highest correlation, and its correlation with "turning on" and "turning off" is also significant. There are four functions, which have obvious correlation with the "cancel" sound sample, and the most relevant is "focus error". The sound signals of "shutter"

Tab. 2 The operational function's correlation examination

category		Turning on	Turning off	Focus correction	Focus error	Confirmation	Cancel	Shutter	Low battery
Turning on	Pearson Correlation	-							
	Sig.(2-tailed)	-							
Turning off	Pearson Correlation	**0.827	-						
	Sig.(2-tailed)	0.000	-						
Focus correction	Pearson Correlation	0.367	0.373	-					
	Sig.(2-tailed)	0.134	0.128	-					
Focus error	Pearson Correlation	0.056	0.439	0.356	-				
	Sig.(2-tailed)	0.824	0.068	0.147	-				
Confirmation	Pearson Correlation	**0.590	*0.561	**0.836	0.213	-			
	Sig.(2-tailed)	0.010	0.016	0.000	0.395	-			
Cancel	Pearson Correlation	0.306	**0.647	**0.665	**0.780	**0.677	-		
	Sig.(2-tailed)	0.217	0.004	0.003	0.000	0.002	-		
Shutter	Pearson Correlation	*-0.543	**-0.807	-0.295	**-0.752	-0.395	**-0.753	-	
	Sig.(2-tailed)	0.020	0.000	0.235	0.000	0.105	0.000	-	
Low battery	Pearson Correlation	0.263	0.530	**0.630	**0.801	0.357	**0.671	*-0.582	-
	Sig.(2-tailed)	0.292	0.024	0.005	0.000	0.146	0.002	0.011	-

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

and other operational functions show the negative correlation apparently. The applicability sound signal of “low battery” has obvious correlation with “focus error”, “focus correction”, and “cancel”.

In general, the functions, which have the correlations, are pretty much. It shows that for the user, except the shutter sound and other functions are showing the negative connection, there is no obvious discrimination in other sound signals for the subject. The significant correlation of the “turning on-turning off”, “focus correction-confirmation”, and “low battery-focus error” are over 0.8. It shows that the three functional groups’ sound signal characters have the commonness in the cognition of sound signal’s applicability.

5. The digital camera’s sound signal SD evaluation result analysis

5.1 SD evaluation factor analysis

This study proceeds the factor analysis through the SPSS statistics software, according to the evaluation result of the 18 sound signals’ 16 SD adjectives from the 50 subjects, Under the circumstance of the component eigenvalue is over 1, to determine the 4 factors are the better ones, and the cumulative variance is 65.23. Each factor’s statistical component value, eigenvalue, and variance are listed in tab.3. The explanations of the four components’ naming are as follow:

1)The component of emotion: This component cluster reflects friendly, euphony, or sense of misgivings, etc., which are the feeling evaluations conveyed by the human psychological emotion, and mainly expresses the sound signal’s emotional feeling. Therefore, it uses “cheerful-misgivings” as the evaluation standard axis of the coordinate, and is named as the “emotion” component.

Tab. 3 SD evaluation factor analysis

Adj.	Component1	Component 2	Component 3	Component 4
acute- euphonious	0.8301	-0.0648	-0.1710	-0.0853
emotionless-friendly	0.8217	0.0717	-0.0051	-0.1335
misgivings- harmony	0.8094	0.1078	-0.0653	-0.0076
strange—familiar	0.6680	0.0908	0.1656	0.2445
low-high	-0.0085	0.8902	0.0192	-0.0823
gliding- lifting	0.1943	0.8195	-0.0001	-0.0937
sharp- smooth	0.4352	-0.6609	-0.2148	-0.0705
heavy-light	0.3564	0.5495	0.3842	-0.1669
soft- strong	-0.2416	-0.1656	0.7371	-0.0580
slow-urgent	-0.1591	0.2307	0.7349	-0.0677
equivocal-definite	0.2235	0.1510	0.7227	0.3291
blur- clear	0.2873	0.3729	0.5045	0.3126
usual- unusual	0.0881	0.1343	0.0437	-0.7461
complicated-simple	0.0351	0.0441	0.3490	0.6888
donkey-vivid	0.3874	0.4226	0.2277	-0.5799
inflectional-flat	0.5039	-0.0099	0.0056	0.5556
eigenvalue	3.8816	2.9639	2.3621	1.2285
% of variance	21.5%	16.7%	14.3%	12.6%
cumulative %	21.5%	38.2%	52.6%	65.2%
component naming	**emotion**	**melody**	**rhythm**	**discrimination**

2) The component of melody: This component cluster is mainly conveying the subject’s feeling towards the sound signal’s melody attribute, tone, contour, timber, etc. So it uses “low-flowing” as the evaluation standard axis, and concludes it as the “melody” component.

3) The component of rhythm: This component is mainly describing sound’s tempo dynamics, speed, and the sound timber or tempo’s clear degree. So it uses “gentle-urgent” as the image standard axis, and is named as the “tempo” component.

4) The component of discrimination: This component is mainly describing the sound signal’s overall image contrast, for instance, “usual-unusual”, “complicated-simple”, etc., to show the general image evaluation. So it uses “usual-unusual” as the image standard axis, and is named as the “discrimination” component.

5.2 Sound signal cluster analysis

This study uses K-means cluster Analysis to analyze the sound signal according to the image character, and set the cluster number as 5 groups after the determination, and take the components, which score over 0.4, as the basis of cluster description. The result shows in tab.4, and the cluster’s samples are organized in tab.5 according to

the sound types and the samples in the clusters. It can be concluded as follow:

1) Cluster1: This cluster's sound signal equips the euphonious psychological trait and slightly gentle physical character. The sample is focus on the dual sound and the melody sound.

2) Cluster2: This type's samples are mainly giving people the sense of misgivings, and the rhythm is slower. The continuous single sound A6, the gliding dual sound, and the spring scale D2 are equipped with this character.

3) Cluster3: The most impressive character of this type's sound signal sample is its low, deep and suppressed tone. The single sound A8 and the gliding sound D4 are belong to this type.

4) Cluster4: The slightly sense of misgivings and the sense of hurried are equipped with the character, which are easy to discriminate from. There are all rather fast rhythms in this cluster.

Tab. 4 Cluster analysis

component	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
emotion	1.0717	-1.2842	0.1083	-0.4591	-0.5330
melody	0.2892	0.1244	-1.6700	0.3821	0.6865
rhythm	-0.4191	-1.0579	0.1222	0.4192	1.8226
discrimination	-0.1322	-0.5043	-0.0743	1.1560	-1.0475
cluster characters	cheerful -- gentle --	misgivings -- gentle usual	-- low -- --	misgivings -- urgent unusual	misgivings flowing urgent usual

Tab. 5 The sound sample's distribution of the clusters

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
A. Single sound		A6(du---)	A8(den)		A1(du) A5(bi~)
B. Dual sound	B8(du-di) B11(dun-di)	B1(du-de)		B3(di-di) B5(dan-dan) B10(di-di)	
C. Simulating sound	C4(Shutter)		C3(Shutter)	C1(Shutter)	
D. Melody sound	D3(lifting) D5(lifting) D6(gliding)	D2(spring)	D4(gliding)		
total	6	3	3	4	2

5) Cluster5: This cluster's images are more diverse. Its have some slightly sense of misgivings and higher tone, and equipped with the urgent feeling, but the discrimination is not good. This cluster is focus on the single sound type's sample.

5.3 Image character analysis

Tab.6 is the distribution situation of the operational function's applicability sample. Comprehensively, because parts of the operational functions have the connection with each other, so it is possible that the same sample may have more than one function. However, it is uncertain that there are quite identical images between each function's sound signals. Therefore, when discussing the corresponding image of the operational functions, this study focuses on the image characters, which are the majority in distribution, below. Among them, there are 6 functions, which have more obvious correlation between functions and clusters, turning on, turning off, focus correct, focus error, confirmation, and cancel.

Tab. 6 The distribution of the operational function's applicability sample in the clusters.

Operation	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Turning on	D3、D5	D2			
Turning off	D3、D6	D2			A5
Focus correction				B3、B5、B10	
Focus error		A6、B1	A8		
Confirmation	B8、B11				A1
Cancel	D6		A8、D4		
Shutter	C4		C3	C1	
Low battery		A6		B10	A5

The applicability samples of the 3 functions, turning on, turning off, and confirmation, are concentrating in cluster1. It can be inferred that these functions are applicable in adopting the gentler and more pleasant sound signals. In the applicability evaluation, these three functions have obvious correlation, so it shows similar situation in the sound signal's image.

The samples of focus correct are concentrating in cluster4, which adopt the urgent, sense of misgivings, and easy to discriminate, sound signals, quite identically. The samples of focus error are using the cluster2 as the primary, applicable in adopting the sound signals, which have slower rhythm and lower tone. The samples of cancel are mainly in cluster3. Its' main character is equipping the quite vivid sense of low, deep and suppress.

Shutter and low battery are two special functions. Both have no clear cluster distribution in the applicability samples, but it is understandable that there is no correlation between the shutter applicability samples .The reason is people can associate directly from experience, and discriminate the meaning on the spot when heard the sound; therefore, its have very high applicability. Although the three samples of low battery have each diverse comprehensive image, there is still one common character among them: the sense of misgivings. It can make the user noticing the severity of low battery easier, and may have higher applicability for this reason.

6. Conclusion and Suggestion

According to the experimental result of this study, it is concluded as follow points:

1) For the user, the digital camera's sound signals, "turning on-turning off", "focus correction-confirmation", and "low batter-focus error", all have the commonness in cognition.
2) The user's image cognition about the digital camera's sound signals is extracted four components by the factor analysis. It can be mainly divided into the emotion component, the melody component, the rhythm component, and the discrimination component, and then divide the 18 sound samples into 5 groups by the cluster analysis.
3) Through the comprehensive analysis of the applicability evaluation and the sound signal's image evaluation, the sound signal's applicability design rules can be concluded as follow:
   a. Turning on: adopting the lifting melody sounds, and the gentler rhythm will be the better.
   b. Turning off: the melody sound, which is gentle in the rhythm, will be more applicable.
   c. Focus correction: adopting the dual sound's types of the same scale. The rhythm is short and clear.
   d. Focus error: is focus on the sense of misgivings and the low melody.
   e. Confirmation: The tone type is the main trait of dual sound. It can collocate with the lifting melody.
   f. Cancel: adopting the low tone and the gliding tone's melody.
   g. Shutter: adopting the shutter simulating sound, for it has the experiential connections, which makes people to cognize and understand easily.
   h. Low battery: The rhythm is faster, and can convey the sense of misgivings in emotion, in order to show the effect of warning.

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