ISASE 2019

Multisensory Integration: Effect of lighting, sound and ambient scenting to support workers' activities in the presentation room

Mai YANAGAWA*, Haruyuki YOSHINAGA **, Izumi TAKAHASHI ***
Seiya ENOMOTO****, Takashi SAKAMOTO†, and Toshikazu KATO‡

* *Air Aroma Japan Pty Ltd, Setagaya Business Square Hills 2, 4-10-3 Yoga, Setagaya-ku, Tokyo 158-0097, Japan*
mai.yanagawa@air-aroma.com
** *KANSEI Projects Committee, Setagaya Business Square Hills 2, 4-10-3 Yoga, Setagaya-ku, Tokyo 158-0097, Japan*
*** *Seiwa Business Co., Ltd, 6-7F Tokyo Tatemono Muromachi Bldg., 4-3-18 Nihombashi Muromachi, Chuo-ku, Tokyo 103-0022, Japan*
****JVC KENWOOD Victor Entertainment Ltd, Shibuya First Tower, 1-2-20 Higashi, Shibuya-ku, Tokyo 150-0011, Japan*
†*National Institute of Advanced Industrial Science and Technology (AIST), 1-1-1 Umezono, Tsukuba, Ibaraki 305-8568, Japan*
takashi-sakamoto@aist.go.jp
‡ *Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo 112-8551, Japan*
kato@indsys.chuo-u.ac.jp

Abstract: Multimodal stimuli are believed to provide greater and richer perceptional experience than that is caused by unisensory information. This study looks at the nature of crossmodal interactions between visual, auditory and olfactory modalities which occur in the same time and space in endeavor to find out the optimal combinations of lighting, sound and ambient scenting to psychologically support different activities in the presentation room. The experiment was conducted in the actual presentation room where 4 types of light settings, high-resolution nature sound and 2 types of ambient scenting were manipulated. 5-Scale Semantic Differential evaluation with 28 KANSEI words was conducted for 24 space samples with unimodal, bimodal and trimodal combinations. Later applied Principal Component Analysis to compare semantic differences in the evaluation structure that was reflected by how unimodal vs bimodal vs trimodal cues from these products created single or combined effects on people's feelings in the space. The visual cues from lighting seemed to have created greater variance than the ones created by crossmodal interactions of auditory-olfactory stimuli, however, each constituent sense modality contributes differently to the integrated perception. This method can be used for verbalizing features of how each modality that occurs simultaneously functions in the integrated experience. It also enables us to select the optimal combinations of products with sensory cues such as lighting, sound and ambient scenting in the space design to support workers' activities.
Keywords: *Multisensory integration, Olfactory communication, High-resolution sound, Crossmodal integration, Space design*

1. INTRODUCTION

There are increasing market interests in creating effective interactions of multimodal stimuli for office design by combining products such as circadian rhythm lighting systems, sound systems and ambient scenting. The office design which supports activities of workers is believed to be more effective to increase overall corporate productivity. A number of studies suggest that integrated multisensory information at any one time confers richer experience than that caused by unisensory information. Researches of sensory perceptions in humans traditionally has been conducted one sense at a time, however, multisensory integration combining several senses has become more important theme to understand how humans accept a coherent perceptional experience in the real life. (Stein and Meredith 1993; Schifferstein and Spence 2002)

In the actual business situations, there are different phases of business discussions occur in the presentation room. It should provide professional and calm environment to give corporate presentations successfully, however, it should also provide more relaxed and personal atmosphere for detailed business discussions with clients followed by the presentations.

In this study, we looked at the nature of crossmodal interactions between visual, auditory and olfactory manipulation and investigated how the constituent unisensory stimuli influence on people's feelings in comparison to bimodal and trimodal patterns. We conducted the experiment in the actual office space where the circadian lighting system and the high-resolution sound system were installed to evaluate the combinations of lighting and sound as the integrated experience. A scent is presented with blotters in the

environment where visual-auditory stimuli are controlled by the system.

2. EXPERIMENTAL ENVIRONMENT AND METHOD

2.1 Design of experimental environment

The presentation room at Seiwa Business Co., Ltd was used for this experiment. The circadian rhythm lighting system with Nichiei Intec DA-100-07 down lights and NL-FT401 trough lights was installed in the room of which control system enables us to adjust the color temperature from 3,000K~5,700K with selected illumination intensity. Four types of colors with different levels of illumination intensity were used for this experiment: L1 (Cold & Dark: Natural/42.9lx), L2 (Cold & Bright: Natural/51.2lx), L3 (Warm & Dark: Warm White/56.2lx) and L4 (Warm & Bright: Warm White/68.6lx)

In addition to 4 types of light settings, the high-resolution nature sound system "KooNe" by JVCKENWOOD Victor Entertainment Corp was installed to manipulate high-resolution forest and river flowing sound in the same room. To examine the impact of olfactory stimuli, two commercially distributed scents "Arobalance" and "Ayo" from Air Aroma International Pty Ltd were selected. "Arobalance" is a green odor, which is constructed with the natural scent molecules extracted from green leaves and "Ayo" is more colorfully blended fragrance with Lavender, Bergamot, Pink grapefruit, Frangipani, Orange Blossom, Ylang-ylang, and Sandalwood.

2.2 Evaluation method

20 workers from Seiwa Business Co., Ltd were divided into 4 groups to evaluate 24 different combinations of light settings, sound and scents shown in Table 1 in the presentation room on 6th and 7th of July 2016. All groups participated this experiment during the daytime so that the brightness outside the building won't unevenly affect on their evaluations of light settings and other multimodal stimuli combined. Lighting and sound were controlled by the installed system and fragrances were presented with blotters to each worker.

All workers were instructed to walk around the presentation room each time before evaluating the space to avoid biased impressions caused by the fixed sight from the position where they happen to stand in the room. Once 20 workers completed the evaluations of 24 combinations of light settings, sound and scents with 5-point SD scale, the collected data was analyzed by Principal Component Analysis to get the correlation values.

Table1: Evaluated Crossmodal Space Samples
(Combination of light setting, scent and sound)

Sample#	Lighting	Scent	High Resolution Sound
1	L1	-	-
2	L1	-	Forest・River
3	L1	Arobalance	-
4	L1	Ayo	-
5	L1	Arobalance	Forest・River
6	L1	Ayo	Forest・River
7	L2	-	-
8	L2	-	Forest・River
9	L2	Arobalance	-
10	L2	Ayo	-
11	L2	Arobalance	Forest・River
12	L2	Ayo	Forest・River
13	L3	-	-
14	L3	-	Forest・River
15	L3	Arobalance	-
16	L3	Ayo	-
17	L3	Arobalance	Forest・River
18	L3	Ayo	Forest・River
19	L4	-	-
20	L4	-	Forest・River
21	L4	Arobalance	-
22	L4	Ayo	-
23	L4	Arobalance	Forest・River
24	L4	Ayo	Forest・River

3. RESULT

3.1 Principal Component Analysis

Principal Component Analysis gives two sets of values; Principal Component Loadings and Principal

Table2: Principal Component Loading from 1st to 3rd PC

KANSEI Words	1st PC	2nd PC	3rd PC
official	0.07343119	0.935263235	0.13571973
homey	-0.89996489	-0.316680454	0.196807
public	-0.19051421	0.830741133	-0.17854203
private	-0.52964134	-0.572779595	0.32380424
sharp	0.58114694	0.703587597	-0.28841912
gentle	-0.94407123	-0.019541281	-0.17846854
warm	-0.95178971	0.099356401	0.12249254
icy	0.96116356	0.004988257	0.01122829
proper	0.2325797	0.884303617	0.06246165
casual	-0.5924967	-0.710324473	-0.08168384
bright	-0.71956549	0.659165598	0.04393037
dark	0.80579557	-0.563231515	0.01446512
cold	0.83827446	-0.428679342	-0.15439553
neat	0.6320244	0.543115953	-0.47615337
fresh	0.31598129	0.150467203	-0.90695705
sunk	0.73106941	-0.352158899	0.27641
spacious	-0.4584911	0.680459532	-0.40102383
small	0.67203936	-0.523390559	0.29977917
stagnant	0.66256246	-0.264358598	0.43564649
feel wind	-0.0658877	-0.396745521	-0.87633145
tensed	0.68176196	0.67435485	0.17487626
tough	0.83767257	0.40721497	0.27425026
blurred	-0.2859237	-0.723013579	0.29116971
cool	0.54984718	-0.153560669	-0.77011562
lonely	0.89011039	-0.198248074	0.2281802
tidy	-0.00660746	0.490567581	-0.46017775
relieved	-0.78067748	-0.44665578	-0.12463912
relaxed	-0.78161472	-0.419367653	-0.2389265

Component Scores. The correlation values of 1st to 3rd Principal Component Loadings are shown in Table2.

Likewise, the correlation values for 1st to 3rd Principal Component Scores are shown in Table 3.

Table3: Principal Component Scores from 1st to 3rd PC

Sample #	1st PC	2nd PC	3rd PC
1	7.73930364	-1.19847557	1.430190142
2	3.16213577	-2.89306685	0.057212564
3	2.0515694	-2.15892289	-0.122819976
4	2.32346108	-1.12181281	-2.033235193
5	0.82475529	-1.68189302	-0.661568754
6	1.20369926	-1.4298884	-0.91383413
7	2.88943944	3.51422557	0.600598464
8	1.1425467	0.03432647	0.838332848
9	-0.09002518	-0.72548761	0.219636531
10	-0.91207742	0.76529061	-2.25426383
11	-0.945236	-0.7453735	-0.628439384
12	-0.85211831	-1.00960096	-0.009782701
13	-3.29923486	-0.56992475	3.013154467
14	-2.16709099	-0.94740623	2.046871471
15	-2.57405093	-0.6329643	1.142075859
16	-1.79792564	0.34752984	-0.616867903
17	-2.63689073	-0.69383822	-0.65625199
18	-3.03677223	-0.97408287	0.41493844
19	2.01714475	5.58648891	0.297172091
20	0.26091422	2.92851386	0.42273659
21	-0.56426518	1.35827622	0.782715774
22	-1.85413417	1.20723843	-1.962790745
23	-1.11116286	0.80711736	-0.941092627
24	-1.77398507	0.2337307	-0.46468801

suggests that the warm light settings like L3 and L4 are both suitable for communications, however, a selection of the light settings would be depending on the nature of business discussions and the closeness in relationships with the clients. It is generally preferred to have more relaxed atmosphere to proceed business discussions thus making the space too 'casual' and too 'private' may not be appropriate if you don't know the cliets well. Also if the discussons need to be precise and highly professional, too casual and private lighting may create reserve effects which imply unintended expectations.

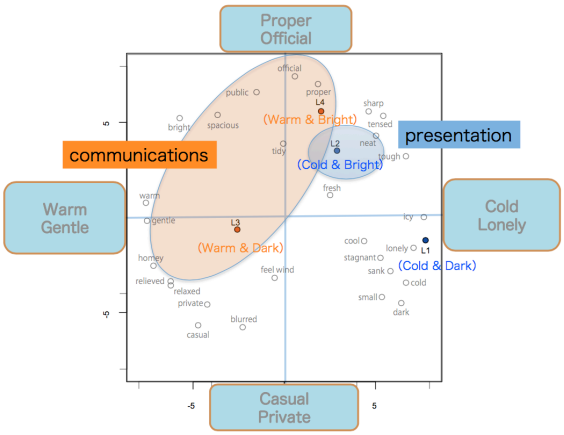

Figure 1: KANSEI map with 1st and 2nd principal components (Comparison of light settings)

3.2 KANSEI map for crossmodal interactions

After calculating values for Principal Component Loadings and Principal Component Scores, KANSEI map can be created with 1st principal component for X-axis and 2nd principal component for Y-axis.

This KANSEI map gives us indications of our semantic evaluation structure across modalities in the same time and space that were manipulated for this experiment. The result of 1st and 2nd Principal Component Loadings shows that horizontal axes has the semantic scaling of "warm" and "gentle" vs "cold" and "lonely" while the vertical axes indicates "official" and "proper" vs "casual" and "private".

Figure 1 is KANSEI map to compare 4 different light settings to see how they influence on our mood differently as unisensory stimuli. L4 (Warm & Bright) is a most "official" and "proper" light setting and less "cold" and "lonly" in comparison to the Cold light settings like L1 and L2. Looking at the differences between L4 (Warm & Bright) and L3 (Warm & Dark), L3 is more "casual" and "private" which is suitable for more relaxed talks with someone intimate. Figure 1

In contrast to warm lighting, the cold lighting seemed to be more suitable for presentations. Prior to this experiment, L1 (Cold & Dark) was ritually used for the presentations in the room believing that they had to make the room darker to use the projecter. However, the result shows L1 luring negative psychological impressions like 'cold' and 'lonely' when compared to L2. L2 (Cold & Bright) creates dark enough environment not to intervene projected images hense it has more positive impressions like 'sharp' and 'proper' when compared to L1.

With this result, it was recommended to use L2 for coporate presentations with the projecter so that more positive psychological impressions are created by the lighting during the presentations.

The difference in effects of lighting from 4 light settings seem to be greater than the ones created by auditory-olfactory integrations thus adding more sensory inputs to the visual cues from lighting could change the whole perceptional experience in the presentation room.

Figure 2 is KANSEI map illustrating the changes of evaluation factors when adding auditory-olfctory stimuli to L4 light setting.

We can see the result of evaluations in combining L4 (Warm & Bright) with auditory-olfactory integrations are dragged towards more “warm” , “gentle”, “casual” and “private” than when L4 is used by itself.

Out of 5 patterns of L4 (Warm & Bright) with auditory-olfactory integrations, L4 (Warm & Bright) combined with KooNe (high-resolution forest and river sound) and Ayo scent was most effective to create “warm”, “gentle”, “casual” and “private” atmosphere than using L4 (Warm & Bright) alone.

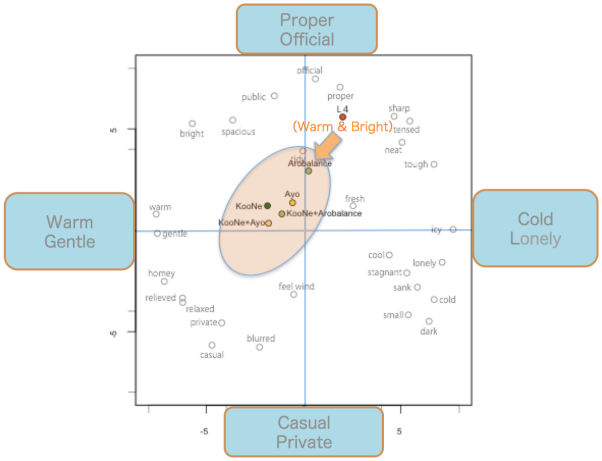

Figure 2: KANSEI map with 1st and 2nd principal components (Comparison between crossmodalities with L4 light setting)

With Principal Component Analysis, we can also examine how specific unimodal stimuli from one product would create the certain values and effects by combining with other modalities in space design.

Figure 3 is KANSEI MAP of 2nd and 3rd principal components and shows how KooNe (High-Resolution forest & River sound) would create multisensory effects by combining different light settings of L1 (Cold & Dark), L2 (Cold & Bright), L3 (Warm & Dark) and L4 (Warm & Bright).

When combined with KooNe, all light settings L1, L2, L3 and L4 are dragged towards more ‘fresh’ and ‘cool’ on the vertical axis which indicates that auditory stimuli from KooNe ceate the integrated effects with all 4 light settings to be more fresh and cooler in the presentation room.

This feature of crossmodal interactions of sound combined with lighting could be more beneficial particularly in summer when the sensory modalities of being ‘fresh’ and ‘cool’ are the desired qualities to increase a comfort level in the presentation room.

The auditory stilumi from KooNe also influenced on the bright lighting of L4 (Warm & Bright) and L2 (Cold & Bright) to be more ‘casual’ and ‘private’ in the presentaiton room.

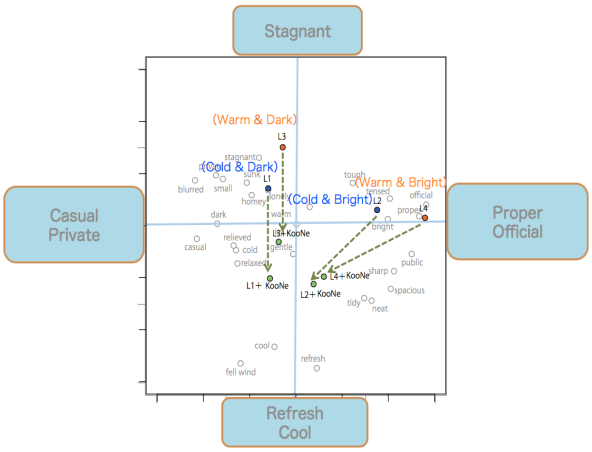

Figure 3: KANSEI map with 2nd and 3rd principal components (Comparison between lighting and visual-auditory crossmodality interactions)

4. CONCLUSIONS

When presented simultaneously in the same time and space, trimodal stimuli of visual-auditory-olfactory interactions provide greater perceptional experience than the ones created by unisensory stimuli.

Using 5-scale SD method and Principal Component Analysis, we are able to verbalize how each unisensory stimuli and the combined crossmodal interactions contribute to the integrated perceptional experience. This experiment also suggested that each unisensory modality is adding specific values when combined with other modalities.

Objectively understanding verbalized features of interactions between crossmodal stimuli, we can also select the optimal combinations of lihgting, sound and ambient scenting with different sensory cues to design the ideal space to psychologically support workers’ activities.

REFFERENCES

[1] Stein, B. E. and Meredith, M. A.; The merging of the senses, Cambridge MA: MIT press, 1993.

[2] Schifferstein, H.N.J and Spence, C; Multisensory Product Experience, P133-161, Elsevier BV, 2002.