Causal relationship study of human sense for odor

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Keyword: causal relation study, odor, covariance structure analysis, factor analysisi

Abstract

The impressions for odors are subjective and have individual differences. In this study, the impressions of odors were investigated by covariance structure analysis. 46 subjects (men in their twenty) recorded their reactions to ten odorants by grading them on a seven-point scale in terms of twelve adjective pairs. Their reactions were quantified by using factor analysis and covariance structure analysis. The factors were extracted as "preference", "arousal" and "persistency". The subjects were classified into three groups according to the most suitable causal models (structural equation models). Each group had different causal relationship and different impression structure for odors. It was suggested that there is a possibility to evaluate the subjective impression of odor using covariance structure analysis.

Keyword: odor, factor analysis, covariance structure analysis, graphical modeling

Introduction

Odors generally give various influences on human sensitivity. There are diverse factors influencing the odor sense evaluation, such as preference and individual difference. Since the human impression of odors is subjective, it is considered that objective and quantitative expression of the impression for them is very useful[1]. However, there isn't almost the objective standard of the impressive evaluation about them.

This work studied on the causal models of the impressive structure for odors by covariance structure analysis[2] and graphical modeling[3].

Experimental

Table 1. Adjective words for sensory test

No.	Adjectuve word
1	dirty – clean
2	delicate – coarse
3	deep – superficial
4	hot– cool
5	wam – cold
6	hard – soft
7	sedate– excitable
8	vague – clear
9	dull – keen
10	permanent – transient
11	unpleasant– pleasant
12	oily – watery

The 10 typical odors used in this work are: phenylethyl alcohol, phenylpropyl acetate, p-toryl acetate, phenylethyl acetate, geranyl

fomate, clitoral, linalool, linalyl acetate, lemon and isovaleric acid. The subjects were 46 men in their twenties. They smelled each odor and grated it a seven-point scale in term 12 adjective pairs, with the result showed in Table 1. The grated responses were analyzed by factor analysis. The extracted factors were quantified by using covariance structure analysis and graphical modeling.

Results and Discussion

The subjects had diverse evaluations of odor sense and individual difference. So, they were classified into three groups according to cluster analysis based on the evaluation of preference.

The evaluation value of each group was subjected to factor analysis (Varimax rotary method) to extract the factor axis and 3 factors were obtained, with the result given in Table 2. In the group 1 and 3, the first factor was named "preference", the second "arousal" and the third "persistency" from the contents of the adjectives included in each factor. Similarly, the first factor named "preference", the second "arousal" and the third "refreshment" in the group 2.

Table 2. Factor analysis

Group 1	Objective factor	Latent factor
1st factor	dirty-clean unpleasant-pleasant	preference
2nd factor	dull-keen vague-clear	arousal
3rd factor	deep-superficial permanent-transient	persistency
Group 2		
1st factor	filthy-clean unpleasant-pleasant	preference
2nd factor	dull-keen vague-clear	arousal
3rd factor	deep-superficial warm-cold	refreshment
Group 3		
1st factor	dirty-clean unpleasant-pleasant	preference
2nd factor	dull-keen sedate-excitable	arousal
3rd factor	deep-superficial permanent -transient	persistency

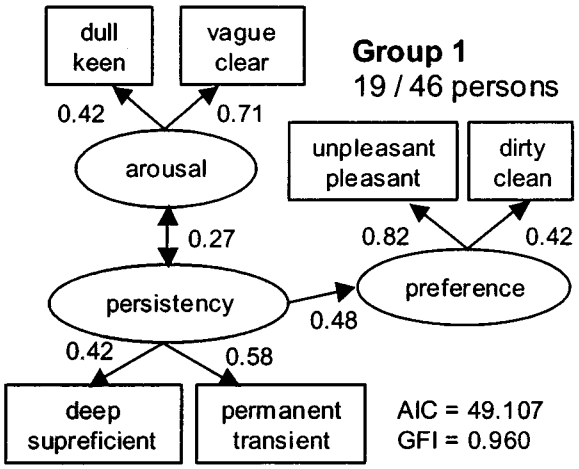

Figure 2 The result of covariance structure analysis in the group 1.

In order to study on the causal relationship of each factor, covariance structure analysis was

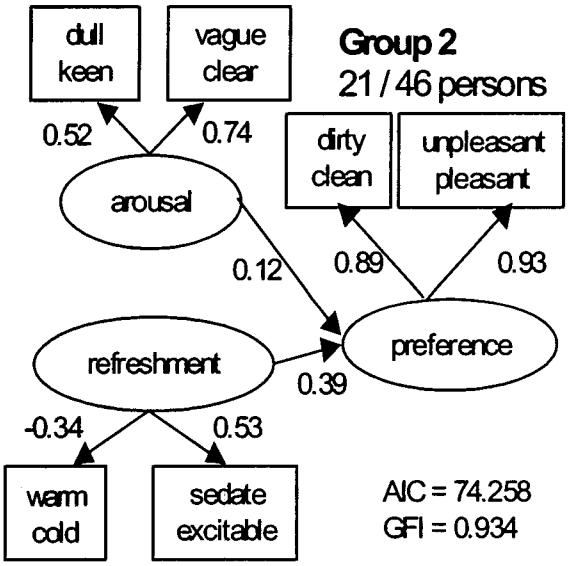

Figure 3 The result of covariance structure analysis in the group 2.

carried out using the extracted factor. Figures 2~4 show the results of covariance structure analysis in each group. In the figures, variables surrounded with square are observed variable and latent variables are surrounded with ellipse. The numerical values represent the

cause coefficient. Where, GFI and AIC in each figure are respectively goodness of fit index and Akaike's information criterion, which show degree of the fitness for the result. If GFI is close to 1 and AIC is smaller, the result shows the good fitness. It is considered that degree of the fitness in each group was the good fitness for values of GFI and AIC.

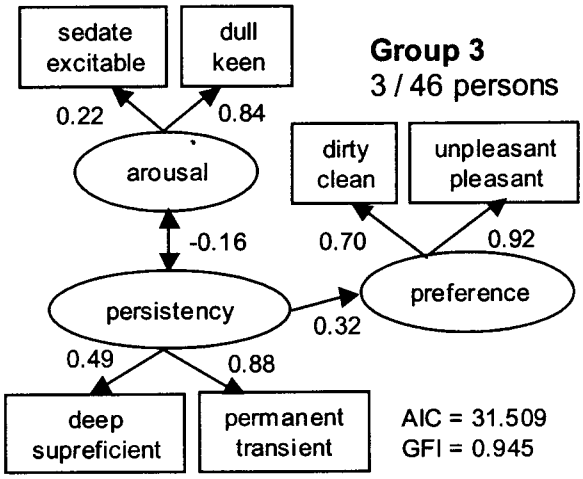

Figure 4 The result of covariance structure analysis in the group 3.

In the group 1 (shown in figure 2), there was no path from arousal to preference, but there was the path from persistency to preference. This implies that persistency influences preference at least. On the other hand, there was the path between arousal and persistency. This shows the correlation between arousal and persistency, and implies that these factors are similar in odor sense each other. In the group 2 (shown in figure 3), there were the paths from arousal and refreshment to preference. This shows that both of arousal and refreshment influenced preference. In the group 3(shown in figure 4), pattern of the impressive structure was similar to that in the group 1, but the value of the path between arousal and persistency was negative. This shows that the both sensory character of the odors was in inverse proportion to each other.

Resulting from covariance structure analysis, the subjective impression of the odors could be visually expressed by 4 latent variables (arousal, persistency, refreshment and preference). Each group had different causal relationship and a preference tendency of it.

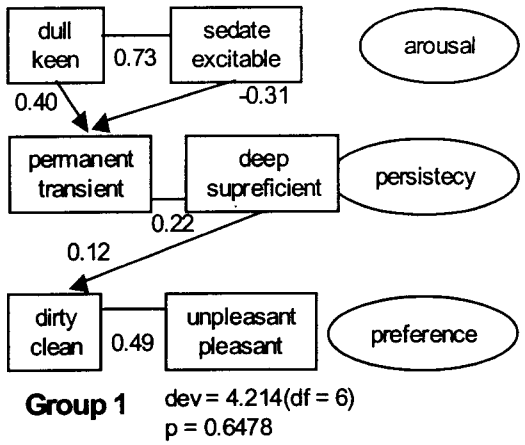

Figure 5 The result of graphical modeling in the group 1.

Next, Graphical modeling was carried out to clarify the relationship of each observe variable (evaluation value) in the causal model. Figures 5~7 show results of graphical modeling in each group. Where, dev and p in each figure are respectively deviance and probability of it. In this work, we defined degree of fitness as p ≒ 0.50 to simplify graphical modeling. And we tried to analyze graphical modeling many times until p was the closest to 0.50. In figures, the numerical

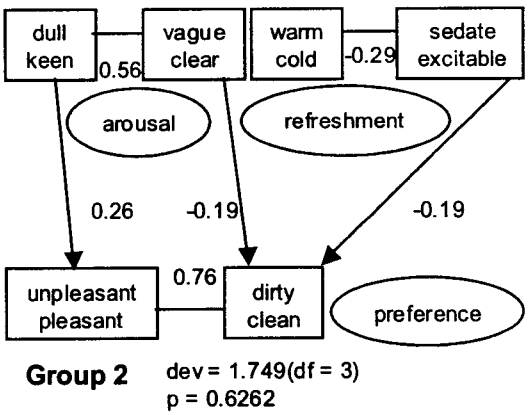

Figure 6 The result of graphical modeling in the group 2.

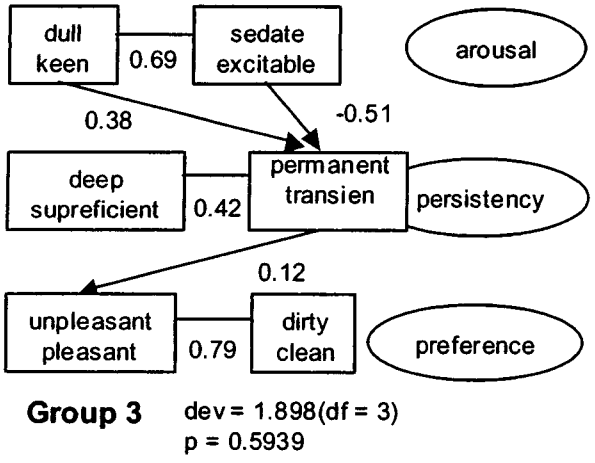

Figure 7 The result of graphical modeling in the group 3.

values represent the correlation coefficient. In the group 1 (shown in figure 5), the variables "dull-keen and sedate-excitable" on factor "arousal" were related to the variable "permanent- transient" on factor "persistency". The variable "deep-superficial" on factor "persistency" was associated with the variable "dirty-clean" on factor "preference". In the group 2 (shown in figure 6), each variable on factor "arousal" and "refreshment" was concerned with both variables on factor "preference". In the group 3 (shown in figure 7), modeling in this group was roughly similar to that in the group 1. But, each variables "permanent-transient" on factor "persistency" was related to the variable "unpleasant-pleasant" on factor "preference". It was found that the correlation of variable could be visually presented in each group using graphical modeling.

Thus, It is considered that covariance structure analysis and graphical modeling are very useful for evaluating the human subjective impression of odors.

Conclusion

The impressions for odors were investigated using covariance structure analysis and graphical modeling. Ten fragrances representing typical odors were evaluated by 46 subjects who grated them on a seven-point scale. The subjective impression of the odors could be objectively expressed by 4 latent variables such as arousal, persistency, refreshment and preference. The subjects were classified into three groups according to the most suitable causal models. Each group had different causal relationship and different impression structure for odors. It was suggested that there was a possibility to evaluate the subjective impression for odor using covariance structure analysis and graphical modeling.

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