Smell Recognition and Odor – Shape Matching

Babür Erdem[1]*, Kerem Alp Usal[2]*, & Annette Hohenberger[2]

1) Department of Biological Sciences, Faculty of Arts & Sciences, METU, Ankara, Turkey
2) Department of Cognitive Science, Informatics Institute, METU, Ankara, Turkey
*These authors contributed equally to this study.
E-mail of corresponding author: hohenber@metu.edu.tr

Introduction

Same cortical areas, namely dorsal and ventral prefrontal cortices, are involved in working memory for both visual and olfactory stimuli (Dade, Zatore, Evans & Jones-Gotman, 2000). In the human brain, piriform cortex is the most important cortical area for olfaction (Howard et al., 2009). and cross-modal memory retrieval for vision and olfaction (Gottfried, Smith, Rugg & Dolan, 2004). Another study also showed a significant activation in hippocampus during trials in which odor and visual cues were related, and attributes the cross-modal association to the hippocampus (Gottfried & Dolan, 2003). The literature in the field suggests that odor cues facilitate visual recognition (Cann & Ross, 1989).

The aim of this study is to assess the correlation between different modalities in object identification, and the ability to associate between different cues. Our research questions are: (i) What is the level of success in smell recognition compared to visual recognition? (ii) Does the level of success differ between odor-shape association and other visual associations? (iii) Does the number of presented objects affect the performance on recognition tasks?

Method

18 participants (9 females, mean age=25.22) were tested in 3 equal groups depending on number of presented objects (2, 3 or 4). All participants were tested with all three tasks: odor-shape association, number-shape association, color-shape association. Task order was counterbalanced. All participants joined the study voluntarily.

Figure 1: Set of odors and smells as they were used in the experiment.

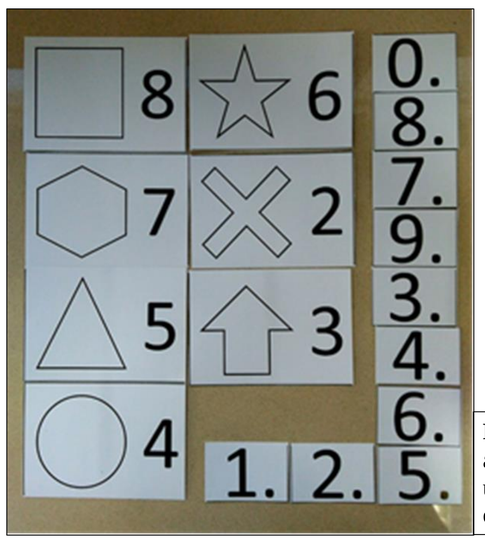

Figure 2: Number and shape cards as used in the experiment.

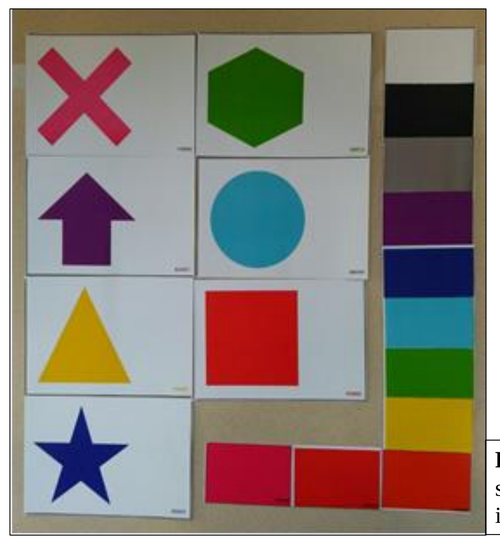

Figure 3: Color and shape cards as used in the experiment.

For odor-shape association, participants were presented with odors on a filter paper in small bottles labeled with shapes (see Figure 1). Unfamiliar odors were used so people cannot memorize them by their names. Odors were narrow-leaved paperbark (*Malaleuca alternifolia*), Indian sandalwood (*Santalum album*), ylang-ylang (*Cananga odorata*), Turkish sweetgum (*Liquidambar orientalis*), cedar (*Cedrus sp.*), lemon balm (*Melissa officinalis*), and Madonna lily (*Lilium candidum*). Afterwards a 5-minute break was given. Then, they were asked which shapes were presented. After that, novel and presented odors, in random order, were conveyed to participants with air flow from 50 cc plastic syringes and participants were asked if they were presented in the previous phase and if so, which shape was on the bottle.

For number-shape association, participants were shown pairs of shape and number was placed side by side on A6 sized paper (see Figure 2). After a 5-minute break, participants were asked which shapes were presented. Then novel and presented numbers, in random order, were shown and participants were asked if they were presented in the previous phase and if so, which shape was it paired with.

For color-shape association, participants were shown colored shapes on A6 sized paper (see Figure 3). After a 5-minute break, they were asked which shapes were presented. Then novel and presented colors were shown in random order and participants were asked if they were presented previously and if so, what was the shape.

Results

In order to assess the level of success in object recognition, d' values were calculated for each groups which shows the distance between the means of hits and false alarms. For comparison of task success, match scores are determined with true match answers divided by total match answers. Odor–shape matching had lower accuracy (M=0.3222, SD=0.2587) in comparison to number–shape matching (M=0.8700, SD=0.3062) and color–shape matching (M=1, SD=0).

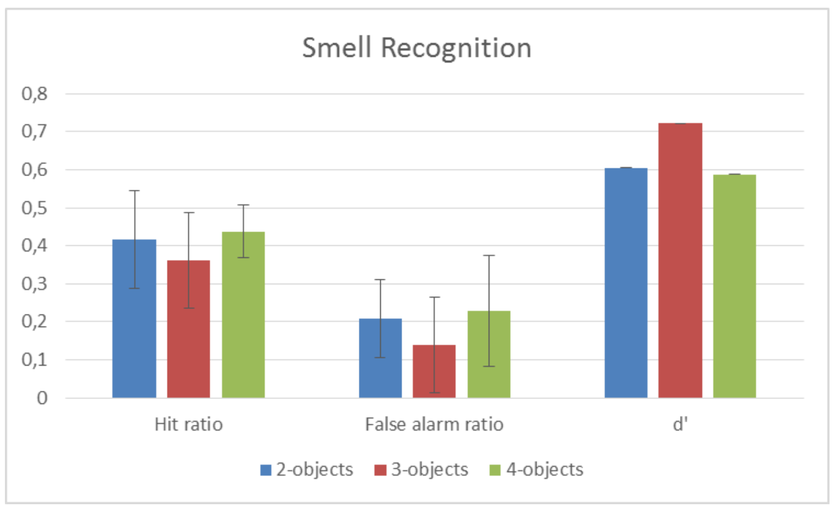

Figure 4: Graphic chart for each group on smell recognition. Error bars show standard deviation.

Table 1: Descriptive Statistics for recognition tasks.

	Mean Hit Ratio (SD)	Mean False Alarm Ratio (SD)	d'
2-Objects	.416 (.129)	.208 (.102)	.605
3-Objects	.361 (.125)	.139 (.125)	.722
4-Objects	.438 (.068)	.229 (.146)	.588

Table 2: Mean Match Ratios(SD) for association tasks.

	Odor-Shape Association	Number-Shape Association	Color-Shape Association
2-Objects	.413(.326)	.888(0.274)	1(0)
3-Objects	.318(.291)	.888(0.274)	1(0)
4-Objects	.235(0.133)	.833(0.408)	1(0)

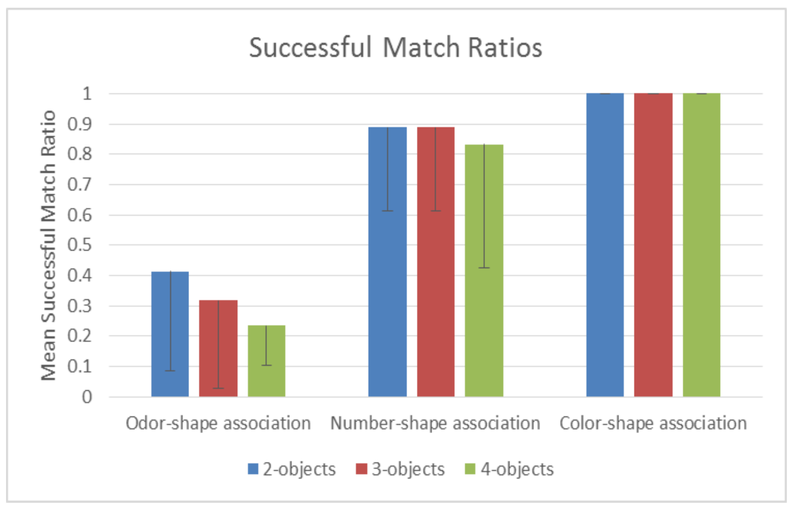

Figure 5: Graphic chart for mean match ratios of each group on all tasks. Error bars show standard derivation.

Conclusion

This study revealed that people are less successful in recognizing novel odors a short while after their presentation, even though they are very successful if the same test is applied with numbers or colors instead of odors. In addition, smell-shape association is similarly difficult for humans to perform whereas number-shape association and color-shape association is performed almost perfectly. Finally, this study also showed that the number of presented objects, at least in the range of 2 to 4 items, do not have a major impact on the cognitive performance. However, it should also be noted that there is at least some level of negative correlation between the number of presented objects and the ratio of successful recognition. The existence of shapes did not facilitate the recognition of odors. The fact that smell is the only sense that does not go through thalamus (Stein et al., 2000) might have an effect on the low success seen in odor-shape association in comparison to other senses.

References

Cann, A. & Ross, D. A. (1989) Olfactory stimuli as context cues in human memory. *The American Journal of Psychology*, 91-102.

Dade, L. A., Zatorre, R. J., Evans, A. C. & Jones-Gotman, M. (2001) Working memory in another dimension: functional imaging of human olfactory working memory. *Neuroimage*, 14(3), 650-660.

Gottfried, J. A. & Dolan, R. J. (2003) The nose smells what the eye sees: crossmodal visual facilitation of human olfactory perception. *Neuron*, 39(2), 375-386.

Gottfried, J. A., Smith, A. P., Rugg, M. D. & Dolan, R. J. (2004) Remembrance of odors past: human olfactory cortex in cross-modal recognition memory. *Neuron*, 42(4), 687-695.

Howard, J. D., Plailly, J., Grueschow, M., Haynes, J. D. & Gottfried, J. A. (2009) Odor quality coding and categorization in human posterior piriform cortex. *Nature Neuroscience*, 12(7), 932-938.

Stein, T., Moritz, C., Quigley, M., Cordes, D., Haughton, V. & Meyerand, E. (2000) Functional connectivity in the thalamus and hippocampus studied with functional MR imaging. *American Journal of Neuroradiology*. 21(8): 137–401.