

# Cross-Modal Associations Between Odors, Colors, and Abstract Visual Forms

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## Abstract

We explored the relative strength of odor-evoked associations with colors and shapes. In experiment 1, participants matched odors with colors and also indicated whether each odor smelled “sharp” or “round”. Most odors were strongly associated with colors and were clearly categorized as either sharp or round. In experiment 2, *color* and *shape* dimensions were presented simultaneously in figures to be matched with odors. Color associations were found to be more robust than shape associations.

## Introduction

- A long line of research has demonstrated cross-modal associations between **odors** and **colors** (Zellner, 2013).
- Colors create expectations that influence odor hedonics, intensity, and identification (see Zellner, 2013 for review).
- Participants match colors with odors on the basis of learned semantic associations or on the basis of amodal stimulus features (bright colors matched with odor intensity) (Maric & Jacquot, 2013; Dematté, Sanabria, & Spence, 2006).
- A separate line of research has demonstrated equally robust cross-modal associations between **odors** and **visual forms**.
  - Some odors (lemon, pepper) are associated with angular & sharp visual forms, while others (vanilla, raspberry) are associated with smooth & rounded forms (Hanson-Vaux et al, 2013).
  - Odorants that stimulate the trigeminal system (eg. acetone, sage, menthol) are more likely to be associated with **sharp** shapes, while non-trigeminal odorants (vanilla, jasmine) are associated with **rounded** shapes (McCall, Goubet, Engelman, & Willis, 2011).
  - Like odor-color associations, odor-shape associations may be learned or may arise from amodal stimulus features (such as intensity or pleasantness; Hanson-Vaux, et al, 2013)

## Current Experiments

- Compare the relative strengths of these two classes of odor associations – odor-color vs. odor-shape
- Experiment 1: Identify a set of odors that are strongly associated with specific colors and are either “sharp” or “round”.
- Experiment 2: Test whether **color** or **shape** takes precedence when the two dimensions are presented simultaneously.

## Experiment 1 – Identify a set of odors with strong Color and Shape associations

- Participants (n=18) smelled 15 unlabeled odors presented in 60-ml amber glass bottles and chose which of 10 basic colors best matched each odor. They also indicated whether each odor smelled “Sharp” or “Round”.
- Chi-square analyses determined that eight odors had consistent color and shape associations ( $p < .01$ ).

Table 1. Significant associations between odors, shapes, and colors from Experiment 1. Non-associated colors were chosen by 0 participants (will be used in experiment 2).

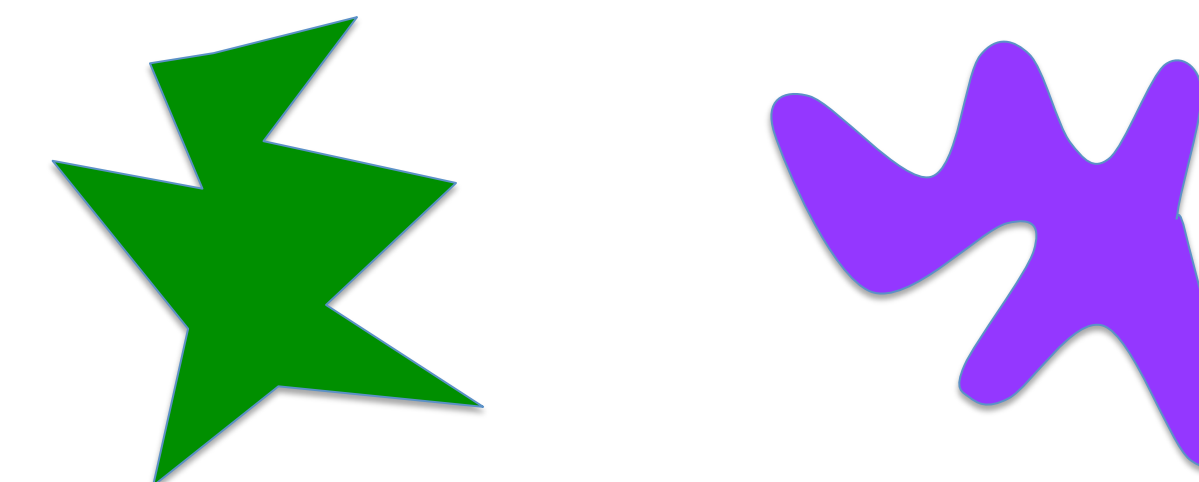
Odor	Associated Shape	Associated Color	Non-Associated Color
Maple	Round	Brown	Yellow
Banana	Round	Yellow	Green
Blueberry	Round	Blue	Brown
Brandy	Round	Purple	Orange
Orange	Sharp	Orange	Black
Anise	Sharp	Black	Red
Cinnamon	Sharp	Red	Blue
Peppermint	Sharp	Green	Purple

## Experiment 2 – Color vs. Shape

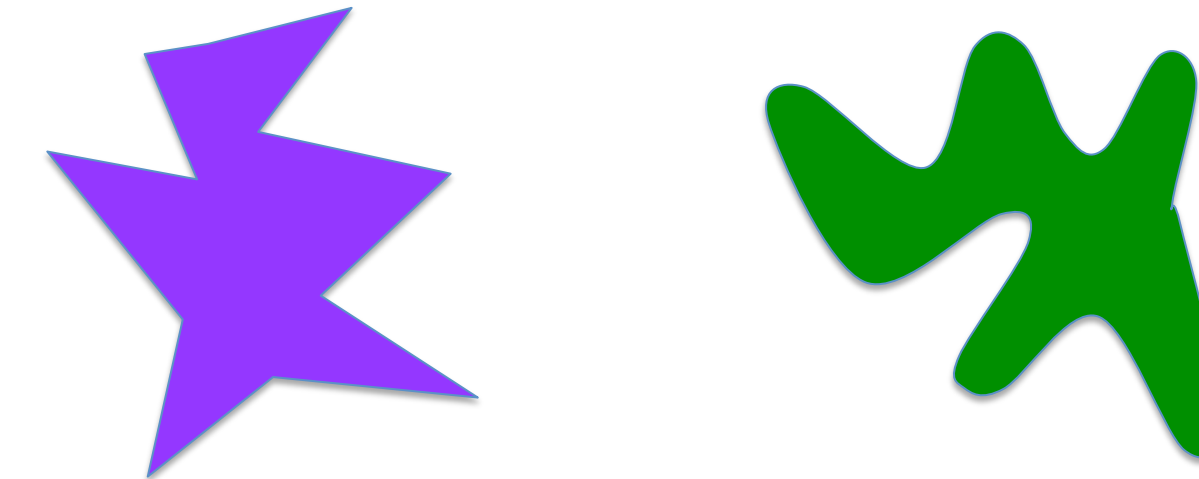
- Participants (n=28) smelled each of the 8 odors from table 1, and chose which of two colored shapes best matched each odor. The set of odors was presented twice in block randomization.
- 2 Conditions (within subjects):
  - Coupled** condition: one of the two shapes matched the odor in color and shape (according to the associations found in experiment 1)
  - Uncoupled** condition: Shape and Color dimensions were split. One figure matched the odor by its shape (either rounded or sharp), but was colored in the non-associated color. The other figure had the opposite shape but matched the odor by its color.

Sample Figures for PEPPERMINT odor (which was found to be associated with “sharp” and the color green in Experiment 1)

Figures presented in the **Coupled** trials:



Figures presented in **Uncoupled** trials:



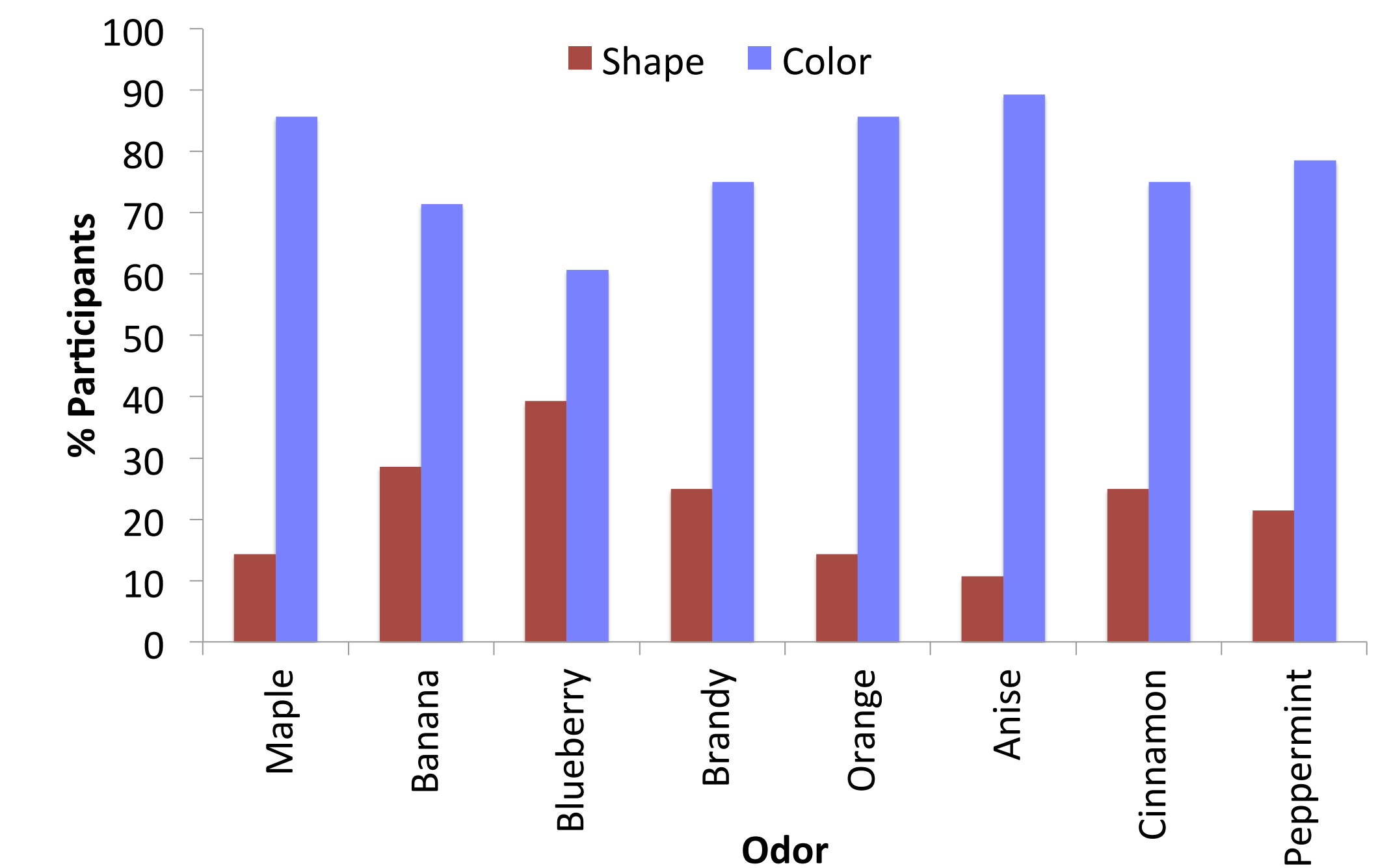
## Experiment 2 - Results

**Coupled condition:** Participants chose the matching figure on a mean of 6.86 (SD = 1.38) odors out of 8, confirming the strong associations found in experiment 1.

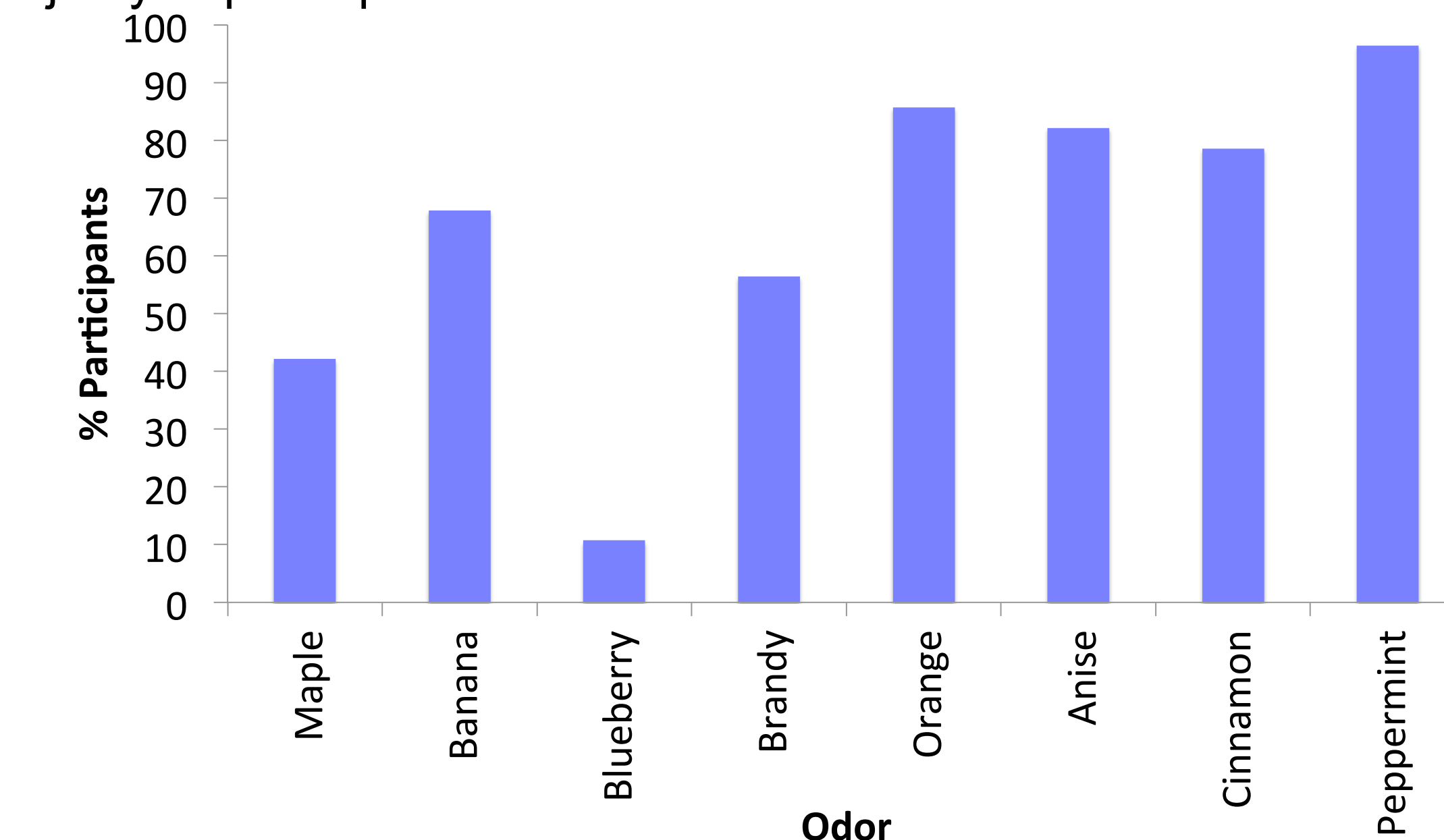
**Uncoupled condition:** Participants chose the figure that matched by color ( $M = 6.21$ ,  $SD = 1.77$ ) for more odors than the figure that matched by shape ( $M = 1.79$ ,  $SD = 1.77$ ). The difference between the coupled and uncoupled conditions was significant,  $t(27) = 10.28$ ,  $p < .001$ ,  $d = 1.94$ .

## Experiment 2 – Results (cont.)

**Odor by odor comparison (fig.2):** For all odors except blueberry, a greater number of participants than expected by chance matched the odor to the corresponding **color** rather than its **shape** (binomial  $p < .05$ ).



**Odor Identification (fig.3):** Six of the 8 odorants were identified by a majority of participants.



## Conclusions

- Although both colors and shapes were strongly associated with odors when tested individually, color appeared to be more strongly associated than shape.
- The high rates of odor identification suggest a semantic basis for this finding. An odor’s semantic representation likely includes its color, but not “sharpness” or “roundness”, which is considered an amodal perceptual property. The finding that blueberry, which was poorly identified, was in turn weakly associated with color supports this idea.
- All of the odors were food-related. These odors may be more strongly associated with color than with shape because through experience, food odors may be encountered in differing shape contexts while color remains consistent. Future studies should explore non-food odors or unfamiliar odors to further examine the role of semantic processing in underlying these associations.

## References

- Dematté, M.L., Sanabria, D., & Spence, C. (2006). Cross-modal associations between odors and colors. *Chemical Senses*, 31, 531-538
- Hanson-Vaux, G., Crisinel, A., & Spence, C. (2013). Smelling shapes: Crossmodal correspondences between odors and shapes. *Chemical Senses*, 38, 161-166.
- Maric, Y., & Jacquot, M. (2013). Contribution to understanding odour-colour associations. *Food Quality and Preference*, 27, 191-195.
- McCall, D.D., Goubet, N., Engelman, J., & Willis, D. (2011). Round vanilla and pointed grapefruit. Poster presented at meetings of the Association for Psychological Science.
- Zellner, D.A. (2013). Color-Odor Interactions: A review and model. *Chemosensory Perception*, 6, 155-169.