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The Effect of Visual Images on Perception of Odors

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Introduction

We make full use of our sensory system, chiefly the visual system, to recognize objects around us. The visual and auditory systems are extroceptive systems, which can detect an object from a distance. On the other hand, gustatory and somatosentory systems are introceptive systems, which can detect an object only when the object is located near us. The olfactory system has both extroceptive and introceptive characteristics. But the effective distance from objects for theolfactory system is nearer than for the visual system. Thus it is highly adaptive to depend on the visual system to recognize objects in the external world.

We recognize an object firstly by the visual system and then we turn our attention to the object and determine its other sensory characteristics, e.g. its odor. As Dalton (2002) described in her review, olfaction has a strong tendency to be affected by top-down (or conceptually driven) processes. Thus, it is hypothesized that we perceive and recognize an object's odor under the influence of a top-down process driven by the visual system.

In this paper, we first review the research on effects of vision (color) on olfactory perception and then we review studies concerning the effects of visual images (pictures) on olfactory perception. We then introduce a concept of this phenomenon.

Colors and flavors

Some researchers have reported that colors of odor stimuli affect identification of odors. Blackwell (1995) reported that participants misidentified orange flavor solution as lime when it was colored green. Morrot *et al.* (2001) found that red-colored white wine was identified as red wine by 54 tasters. Sakai (2004) found that almost all participants correctly identified a cola-flavored solution when it was colored dark brown, but that many participants misidentified a cola-flavored solution as orange or tea flavor when it was colored orange. On the other hand, an orange-flavored solution was correctly identified when it was colored orange, but it was misidentified as tea or grape flavor when it was colored dark brown. These results show there are many pairings of colors and flavors that show interactions, suggesting that these interactions occur t a cognitive level, not at a peripheral or physicochemical level.

The reason for this phenomenon is explained using the association between the olfactory and visual systems. We make associations between odors and colors, e.g. cola flavor and black solution, orange flavor and orange solution and so on, through daily experience. According to this cognitive mechanism model, we make an association between the flavor and the color of a beverage and we retain this association in the brain. When we see the color of the beverage again, we have an expectation of the flavor of the beverage. Thus, when the 'real' flavor is the same as our expectation of the flavor, we can easily identify the flavor. These pairings of flavors and colors are called 'appropriateness', 'congruency', or 'matching'. On the other hand, when the 'real' flavor is different from the expectated flavor, we must cancel the initial expectation and then concentrate our attention on perception of the actual flavor.

This hypothesis is supported by the work of Zellner *et al.* (1991), who found that participants identified flavors more correctly when they were appropriately (e.g. red–strawberry) colored than when they were colored inappropriately (red–lemon). They also showed that participants took more reaction time to identify flavors in inappropriate combinations of color and flavor than in appropriate combinations.

In contrast to these results of flavor identification, the effects of color on flavor intensity are complicated. For example, Zellner and Kautz (1990) found that flavor solutions with color were judged as smelling more intensely than equally concentrated flavor solutions without color. However, there is no difference in enhancement between appropriately colored solutions and inappropriately colored solutions. Zellner and Whitten (1999) also reported that coloring of the flavored solution enhanced perceived odor intensity and that color appropriateness had only a small effect on evaluation of odor intensity. In this study, color intensity, rather than color appropriateness, had more effect on perceived intensity of odor. They discussed appropriateness of color as a 'trivial contributor' for color-induced odor enhancement.

This inconsistency in the effect of appropriateness of color on odor perception can be interpreted as follows. When we are asked to evaluate the intensity of an odor, we concentrate our attention on odor intensity. In other words, in this case, we do not pay attention to what the odor is or whether we identify the odor correctly or incorrectly. Thus, color only enhances our expectation of odor intensity. In this point of view, the color may not be enough to evoke a strong (or concrete) image of an odorous object.

Visual images and odors

Although the preceding studies used only flavors and colors, we also experience aromas, visual images (shapes, movement and so on) and their interactions. In our everyday lives, we simultaneously experience odor and visual images of objects from which the odors may come. Thus, it is better to use visual images (e.g. pictures or movies) than colors when we want to evoke more real images of odorous objects.

Here, a part of the authors' study is introduced. Twenty-four healthy university students participated in this study. Nine odors from the set of the Odor Stick Identification Test (Saito *et al.*, 2003) and several pictures for each odor were used as stimuli of odors and visual images, respectively.

First, participants were asked to smell an odor and to evaluate their preference for the odor. After evaluation of odors, the participants were presented nine pictures and asked to select a picture that was most appropriate for the odor and a picture that was least appropriate for the odor. Participants repeated this procedure nine times (for each of the nine odors).

Participants were then asked to evaluate the intensity of and their preference for an odor presented with pictures, one of which (X) was most appropriate for the odor and the other (Y) was inappropriate for the odor. Participants repeated this procedure for each of the nine odors (thus, they evaluated 18 times in this experiment). When the odor was presented with X, the evaluated intensity was significantly higher than in the case when it was presented with Y. From this result it is suggested that appropriate pictures enhanced evaluation of odor intensity.

Preference ratings for odors which rated as preferable in the preliminary study were significantly higher when they were presented with picture X than those presented with picture Y. On the other hand, preference ratings for odors which were rated as undesirable in the preliminary study were significantly lower when they were presented with picture X than those presented with picture Y. Thus, it is suggested that appropriate pictures also enhanced evaluation of odor preference.

Cognition and odor perception

These results seem to indicate that the visual stimulus used in this study had evoked the object's image strongly enough to give rise to an expectation of the object's odor. Then, this expectation enhanced the perceived intensity and preference for the odor. These results have been supported by several studies, which used words instead of visual images to evoke expectation for odors.

Dalton (1996) found that participants who were told that the odor was a 'natural' or 'healthy' extract showed adaptation to the odor, but that participants who were told that the odor was hazardous showed sensitization to the odor. Sakai *et al.* (2004) also found that participants who received negative information about an odor showed weaker adaptation to the odor than those who received positive information about the odor. These studies suggest that information about an odor led to the formation of an expectation for the odor and that this expectation affected perception of the odor.

Distel and Hudson (2001) found that participants appropriately informed about an odor identified the odor more correctly than those informed inappropriately. They also found that appropriately informed participants evaluate an odor as being more intense than those informed inappropriately. These results are consistent with those reported here, in which pictures were used instead of verbally presented information. Thus, it is suggested that words, pictures and colors evoke common mental images for objects and that these mental images lead us to form expectations to the odors.

Several studies have reported that olfactory images for tastes are developed by association between vision and olfaction (e.g. Stevenson *et al.*, 1998; Sakai and Imada, 2003). It is conceivable that associations between vision and olfaction in our daily lives also develop visual images for odors. The association between visual images and odors still remains unclear.

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