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# The Impact of Olfactory Cues on Attention: The Case of Stroop Interference

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## Abstract

This study explores the relationship between odor imagery, color associations, and visual attention through a Stroop-task based on common odor-color associations. This Stroop-task was designed using three fruits with odor-color associations: lime with green, strawberry with red, and lemon with yellow. Each possible word-color combination was lexically presented in the experimental trials. Three experiments were conducted that used the Stroop-task with different odors present. They suggest that odor imagery can affect visual attention, the inhibition of odor-color associations, and that odor imagery appears to be facilitated in the presence of a related odor.

## Introduction

There is increased interest in the study of cross-modal interactions in the production of perceptions, and in studying its effects on attention. One of the most consistently observed cross-modal association is between certain odors and colors (Demattè, Sanabria, & Spence, 2006; Jacquot, Noel, Velasco, & Spence, 2016; Spector & Maurer, 2012). Odor-color associations have been demonstrated to occur relatively automatically, based on a re-tooled Implicit Association Test (Spence & Deroy, 2013). There is also evidence to suggest that odor-color associations are consistent across North American and European cultural contexts (Goubet, Durand, Schaal, & McCall, 2018). These associations between odors and colors have also been shown to have specific neurological effects: when the color and odor of objects are perceived to match, there is increased activity in the orbitofrontal cortex (Österbauer et al., 2005; Skrandies & Reuther, 2008). These neurological findings are consistent with the demonstration that congruency between an odor and color can improve the perception of the odor (Zellner & Whitten, 1999).

Most of the research into odor-color associations has concerned itself with the effects of the visual stimuli of color on the perception of odors (Demattè, Sanabria, & Spence, 2006; Österbauer et al., 2005). However, there is some work that suggests that cross-modal associations between scents and visual stimuli can have effects on vision. For instance, Seo et al. (2010) demonstrated that, when visual stimuli are congruent with present odors, participants attended more to the congruent stimuli.

This study seeks to explore how odor imagery and odor-color associations might interact to effect visual attention and inhibition using a modified Stroop-task.

## Method & Results

The Stroop-task was designed using associations between the odor and color of three fruits (lime, lemon, and strawberry). The name of each fruit was displayed lexically, and the color of the font was one of the three colors associated with the fruit (green, yellow, and red). When the word on screen matched the associated color (lime in green, lemon in yellow, or strawberry in red) the stimuli was considered congruent. Likewise, if one of the fruit-words was displayed in the color not associated with the fruit (e.g., lime in red), then the stimuli was considered incongruent. The participants, in all three experiments, were undergraduate college students, who were offered class credit for their participation. Responses were made by key press (“1” for green, “2” for yellow, and “3” for red). Each word-color combination was displayed 20 times, resulting in a total of 180 trials which consisted of 120 incongruent trials and 60 congruent trials. Response times and errors were recorded.

**Experiment I**

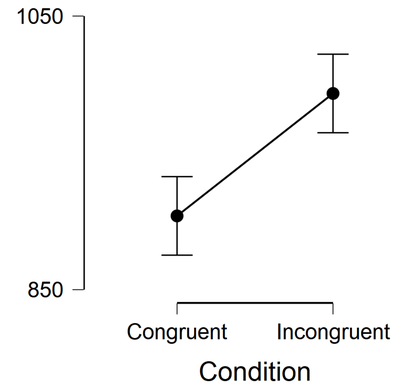
Participants (n = 27) were asked to imagine the odor of the word on the display while responding to the color of the font. There was no significant difference (t(26)=1.82, p=.08) between the congruent (M=900.59, SD=208.31) and incongruent conditions (M=938.67, SD=256.56).

**Experiment 2**

Participants (n = 20) did the same Stroop task but with an orange odorant in the room. It was hypothesized that an odorant related to the other fruits (strawberry, lemon, lime, and orange are all high in citric acid) would enable the imagery and make the odor-color association more prominent, causing a significant difference between congruent and incongruent trials. The participants in Experiment 2 did demonstrate a significant difference (t(19)=2.21, p = .04; d = 0.493) in response time between congruent trials (M = 903.9, SD = 251.5) and incongruent trials (M = 993.4, SD = 371.3).

**Experiment 3**

Experiment 3 was designed to determine if the interference effect is due to any odorant or a task-specific odorant. Participants (n = 14) completed the same Stroop-task as the other two experiments, but with a lavender odorant in the room. As in Experiment 3, there was no significant difference between conditions (t(13)=.95, p =.362).




## Discussion

This study was conducted to determine if olfaction can be used to create cross-modal Stroop interference. While imagining an odor led to some difference between congruent and incongruent conditions, the difference was not significant (Experiment 1). Although Klein (1964) showed that color associated words could also lead to Stroop inference, the fruit words used in this study did not. However, when a fruit odorant was present, Stroop interference was observed (Experiment 2). A non-fruit odorant did not produce Stroop interference (Experiment 3) suggesting that the olfactory information needs to be associated with other stimuli in the task. Together, these experiments indicate that olfactory cues can interact with word and color information resulting in Stroop interference.

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