


2019

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Jonathan K. Ham

Christopher Koch

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

Jonathan K. Ham¹ & Christopher Koch²
¹Temple University ²George Fox University

Summary

Ham and Koch (2019) found that an odorant could influence interference on a modified Stroop task. This study was conducted to examine the impact of olfactory cues on reverse Stroop interference. Across three experiments, participants completed a modified reverse-Stroop task in which they identified a word (strawberry, lime, lemon) in different color fonts (red, green, yellow). Although the words were fruit names instead of color names, each word had some degree of association with a particular color (e.g., lime and green). In Experiment 1, congruent and incongruent trials were presented without an odorant. No differences were found between congruent and incongruent trials ($t(28) = .63, p > .05; d = .12$). Experiment 2 consisted of the same task; however, an orange odorant was added to the room. RTs were faster for congruent trials than incongruent trials ($t(17) = 4.15, p < .001; d = .98$). Lavender odorant was used in Experiment 3 to test whether the RT differences in Experiment 2 were influenced by the presence of a related odorant or any odorant. No differences were found between conditions ($t(27) = 1.89, p > .05; d = .36$). The results indicate that a task-related odorant can impact word identification in a modified Stroop task.

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). There is evidence to suggest that odor-color associations are consistent across North American and European cultural contexts (Goubet, Durand, Schaal, & McCall, 2018). 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 research that suggests that cross-modal associations between scents and visual stimuli can have effects on vision. One study demonstrated that, when visual stimuli are congruent with present odors, participants attended more to the congruent stimuli (Seo et al., 2010).

We recently showed cross-modal Stroop interference using an odorant and fruit words (OPAM poster 28 in Session 2). Across three experiments, fruit words (lime, lemon, and strawberry) were presented in congruent or incongruent colors in the presence of no odorant (Experiment 1), an orange odorant (Experiment 2), and a lavender odorant (Experiment 3). Stroop interference was only found when the orange odorant was present. In this study, we investigate whether reverse Stroop interference can be observed using a similar task.

Method & Results

The reverse 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 (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. Participants identified each word using a key press ("1" for "lime", "2" for "lemon", and "3" for "strawberry"). During the experimental trials, 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. The participants were monitored for response time and error rate across all 180 experimental trials.

Experiment 1

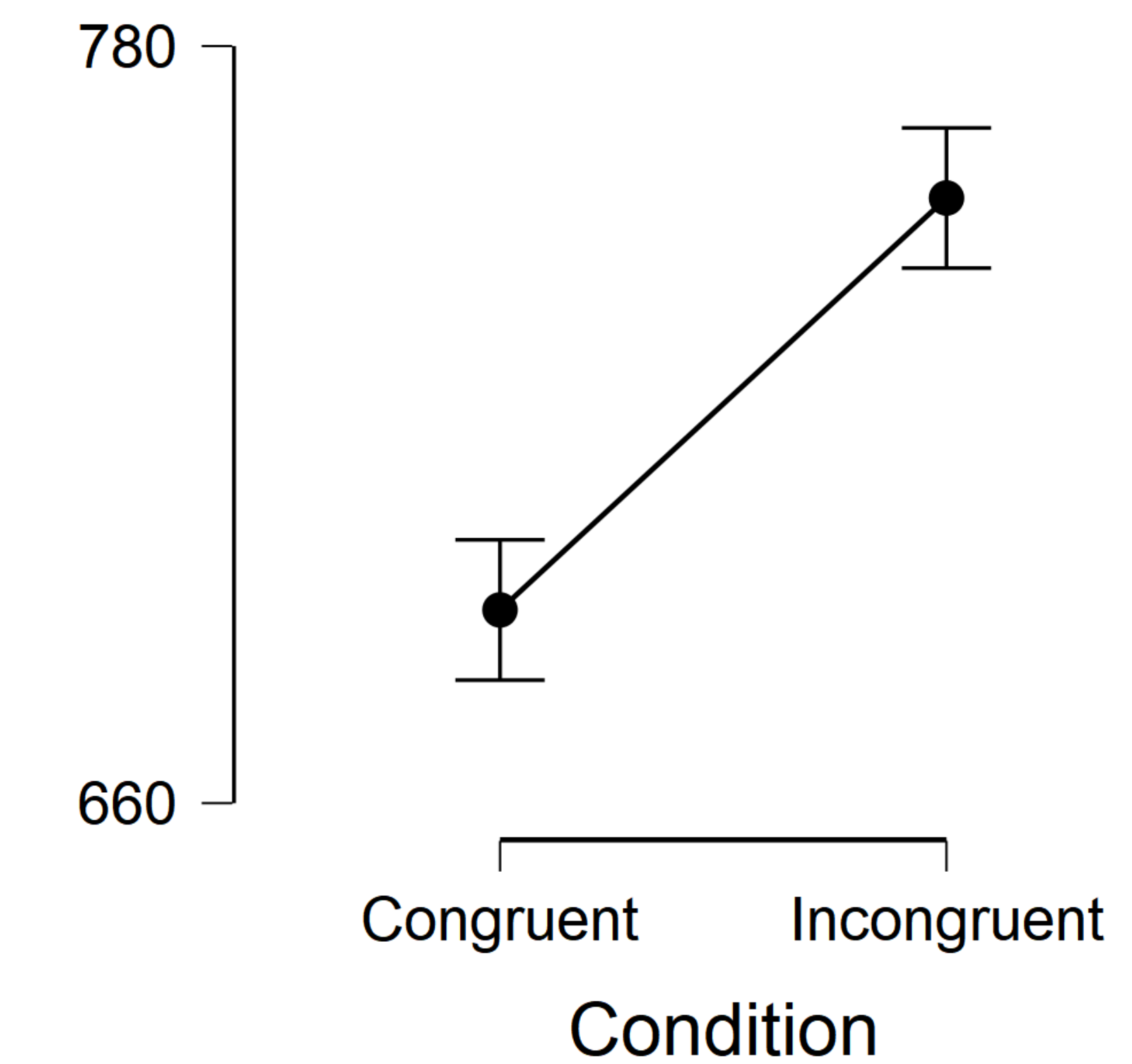
Participants ($n=29$) were asked to imagine the scent of the word being displayed. Congruent words were not identified faster than incongruent words ($t(28) = .63, p > .05; d = .12$).

Experiment 2

Participants ($n = 18$) did the same reverse 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 ($t(17) = 4.154, p < 0.001, d = 0.98$) in RTs between congruent trials ($M = 690.63, SD = 198.82$) and incongruent trials ($M = 755.92, SD = 239.85$).

Experiment 3

Experiment 3 was designed to demonstrate that the significant difference could not be caused by just any odorant, but specifically an odorant related to the color-associated words. Participants ($n = 28$) did the same reverse Stroop-task as Experiments 1 and 2, but with a lavender odorant in the room. The participants in Experiment 3 exhibited no significant difference ($t(27) = 1.89, p > 0.06; d = 0.36$) between congruent ($M = 773.11, SD = 194.10$) and incongruent trials ($M = 814.41, SD = 222.33$).



Discussion

This study was conducted to determine if olfaction can be used to create a reverse Stroop effect. Imagining an odor led to no difference between congruent and incongruent conditions (Experiment 1). However, when a fruit odorant was present, color congruent fruit words were identified faster than incongruent words (Experiment 2). A non-fruit odorant failed to produce a reverse Stroop effect (Experiment 3) suggesting that the olfactory information needs to be associated with other stimuli in the task.

The reverse Stroop effect is not observed as often as Stroop interference (Durgin, 2000). This is likely because reading occurs so quickly. However, there is evidence to suggest when the reverse Stroop effect is observed, it is due to strong associations between the stimuli and the response (Blais & Besner, 2007). Consequently, olfactory information appears to have a strong association with the colors and words used in this study and actually speeds the processing of words. Additional research is necessary to better understand how visual attention is moderated by odors.

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