Incongruent odors suppress perceptual categorization of visual objects

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Introduction

Visual perception is regarded as "dominating" other senses, as participants have a tendency to report only visual features when presented with bimodal stimuli. Theoretical explanations include passive (automatic attention to visual input) and active mechanisms (visual system inhibits non-visual processing). However, a hypothesis is primary role of olfaction is to respond to novelty by attracting attention (3). Prior work shows that olfactory and visual stimuli may influence each other in bimodal tasks (4,5). Here, we focused on whether olfactory or visual objects dominate the other modality when competing for processing resources. "Dominance" was operationalized as "interference asymmetry"; dominant percept should cause exaggerated interference during stimulus incongruity.

Highlights

- Incongruent odors were more distracting for visual categorizations, than vice versa. However, incongruent odor-visual pairs, visual cues received a processing advantage, as predicted by "visual dominance" accounts.
- ERP effects supported our behavioral effects. Bimodal incongruency was processed quickly (320-530 ms post-cue). A late ERP effect (600-900 ms post-tar) incited higher processing effort to classify visual objects in the presence of incongruent odor, than vice versa.
- We suggest a cross-sensory division of labor, based on congruency detection and likely conferring survival benefits; given that hazardous odors are not visible, sources of incongruent odors need to be rapidly identified.
- Our findings reconcile theories of how processing resources are devoted to visual vs. olfactory input.

Participants

Data from 46 healthy adult participants were collected; Behavioral data from n=35 and EEG data from n=30 were included in analyses (mean age 31 years, 16 F).

Analyses

Cluster-based permutation tests of ERP data, contrasting incongruent with congruent, and incongruent/visual with incongruent/olfactory. Linear/logistic mixed effects models (both frequentist and 3x3x3 ANOVA) on single-trial behavioral and ERP data using RSC for generating 95% Credibility Intervals. Analyses were pre-registered at the Open Science Framework website.

Results

Bimodal incongruency led to behavioral impairment in RFs and accuracy levels, and corresponding P30 and P300 and Positive Slow Wave (P) ERP effects. Importantly, odor-incongruent impaired visual processing more than olfactory processing, and an interaction of modality by congruency in the late ERP amplitude (700-900 ms) corresponded to this pattern.

Conclusions

During bimodal incongruence, olfaction displays “dominance” over vision, as evidenced in behavioral response and ERP amplitudes. Predictions from “visual dominance” theories only hold during bimodal congruence. We suggest that the ability of incongruent/unexpected odors to attract attention is a key feature of olfaction, determining perceptual interactions.

References


Method and materials

Object cues were presented as odors and pictures (lilac, pear, lavender, lilac). On each trial, an odor-visual cue was presented; either congruent (e.g., lemon odor, lemon picture) or incongruent (e.g., lemon odor, lavender picture). After a brief delay (1-2s), a target tone indicated which of the two cues should be classified as a fruit or a flower.

Response times and accuracy on congruent and incongruent odors and visual stimuli.

Trial structure

Experimental setup

Congruent vs. incongruent

Incongruent/olfactory vs. incongruent/visual

The predicted ERP (P300, 320-550 ms)

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